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THE PROTOZOA OF MANILA AND THE VICINITY: I

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The student of general zoölogy passes from group to group of the animal kingdom, and in his journey he reviews the

> Edens that wait the wizardry of thought,
> Beauty that craves the touch of artist hands,
> Truth that but hungers to be felt or seen;

until either he pauses at, or goes back to, some group, which has touched his æsthetic sense or stirred his lust for scientific knowledge, and forthwith he becomes a specialist. Probably few men or women who pursue a specialty in natural history are not led to it by some prompting, perhaps very subtle, of the æsthetic sense, which has had its influence in determining them to make a life study of some particular group. To such persons the Protozoa are particularly alluring. Their beauty and variety of form are infinite; their life processes, whether carried out by the most primitive rhizopod or the most complex infusorian, abound with interesting phenomena; and the problems they afford are as profound and fascinating as they are varied and intricate.

Interest in the Protozoa is not restricted to the naturalist or the physician. They offer a fertile field to the amateur microscopist, and indeed, in the past, they have claimed the attention of that person more than they do in this day. Some very important contributions to the study of the morphology of species

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of protozoa have been made by amateur workers. There is scarcely a person whose interest may not be stirred if given the opportunity to watch the rangings of protozoa through the microscopic jungles. The series of papers of which this forms the first is aimed as much to stimulate the interest of the amateur microscopist in a study of our local species of protozoa and a search for new species, as it is designed to be of aid to the general zoölogist and the workers in medicine and other allied fields.

The question "What is a protozoön?" has been answered in a number of ways by different writers. Colloquially they are generally spoken of as "single-celled animals," "the simplest forms of animal life," or "man's ultimate ancestor," definitions that, in the light of our present knowledge of these organisms, are decidedly inadequate. One of the best, if not the best because it is so comprehensive, is that of Calkins,[1] which is as follows:

> A protozoön is a primitive animal organism usually consisting of a single cell, whose protoplasm becomes distributed among many free living cells. These reproduce their kind by division, by budding, or by spore formation, the race thus formed passing through different form changes and the protoplasm through various stages of vitality collectively known as the life cycle.

A brief analysis of this definition should serve to bring out several points, which it is important should be borne in mind by any person who undertakes the study or identification of protozoa.

A protozoön is a primitive animal organism.—The Protozoa are primitive in the sense that their organization as compared with the Metazoa is relatively simple. They have no organic, circulatory, or nervous systems as we understand those things by a study of animals higher in the scale. Their life processes are wholly of a cellular nature, but notwithstanding this they exhibit all the physiological functions manifested by the higher animals. They are considered as animals because, among other things, the animal type of nutrition predominates among them. There are, to be sure, certain species found among the Mycetozoa and the Phytomastigophora that show marked plant characteristics, but which, at the same time, show sufficient animal characteristics to justify their classification with the latter group.

Usually consisting of a single cell.—In a general sense a protozoön taken at random at some stage in its life cycle is a single-

[1] Calkins, G. N., Protozoölogy. Lea & Febiger, Philadelphia (1909), 17.

celled (or, if we accept Dobell's view, a noncellular) organism; but there are many species that tend to group themselves in more or less permanent colonies. Under such circumstances the colony is frequently spoken of as if it were an individual. However, when comparing the protozoan individual to the metazoan individual, the tendency is to consider the entire race produced between successive fertilization processes in the protozoön as being equivalent to the individual metazoön. This view, as Dobell points out, is open to serious question.

Whose protoplasm becomes distributed among many free living cells.—In the process of reproduction, and this varies greatly among the Protozoa, the original cell completely loses its individuality, unless we except forms where the parent cell survives following a process of gemmation. As a rule, however, the original cell becomes divided into two or more individuals, each consisting of a portion of the protoplasm that originally constituted the parent cell. This process goes on in geometrical progression, accompanied by the usual growth phenomena, until the protoplasm of the first cell has literally become distributed among a large number of free daughter cells.

These reproduce their kind by division, by budding, or by spore formation.—Reproduction by division may either be by binary fission, in which the parent cell divides to form two daughter cells, which in time grow to resemble the parent cell; or by multiple fission, in which the parent cell divides to form many daughter cells, which later grow to the adult form. Budding involves the pinching off from the parent cell of buds of nucleated cytoplasm of varying sizes according to the species, the buds in time assuming the form of the parent. The parent cell may or may not survive. Spore formation is often an exceedingly intricate process, among the attendant phenomena being the encapsulation of the organism in a resistant cyst or spore case. Spore formation, in the true sense, is accompanied by a fertilization process.

The race thus formed passing through different form changes.—Therein lies one of the greatest obstacles to the amateur systematist in his work with the Protozoa. It brings to mind the dictum of Schaudinn, "Die Kenntniss der Entwickelung ist das erste Postulat der Protozoenforschung," to which Calkins has added: "Until the full life history is known we can only place forms provisionally and with the understanding that further research alone will establish finality." The experienced protozoölogist has little trouble in recognizing the com-

moner species, but even there the principle does not fall, because he is able to recognize them at any stage of their life cycle. Compared with the whole, especially in regard to the Sarcodina and Mastigophora, the number of species in which it is possible to do this unerringly is not so large as might be imagined. *Paramecium* seen a few times is generally quickly recognized even by the student, and the same may be said of *Vorticella, Spirostemum,* or some of the other relatively monomorphic species. But there are many protozoa that may be amœboid at one stage in their life cycle and flagellated at another; or witness the numerous striking form changes in *Plasmodium, Coccidium, Polystomella,* or even as familiar a form as *Arcella* during the course of their life cycles. These changes in form are of such a pronounced nature in some species as to lead the inexperienced worker to designate as a new species a cell that may merely represent a stage in the life cycle of some already well-known species. Such mistakes have been even committed by experienced workers. No species of protozoa is absolutely monomorphic. Some, it is true, have a very stable morphology, but even there polymorphism may express itself in no more pronounced way than in slight but none the less constant variations in size at definite periods of the life cycle.

The placing of a protozoön in one of the great groups may even involve the arbitrary naming of some stage in its cycle as the "adult" stage. The determining of the protozoan adult is not nearly so simple a matter as it is in the case of the metazoön, where sexual maturity is a convenient landmark, and it sometimes happens that a given species may be placed in either one of two subphyla with perfect propriety. This is particularly true of some of the simpler amœbæ and flagellates.

And the protoplasm through various stages of vitality.—In other words, the physiological vigor and activity of the organism is not constant throughout its entire life cycle. This introduces the question of the immortality of the protozoan cell, which was raised by Weismann in his contention that every protozoön was a potential germ cell. This view has been vigorously combated by Calkins, who has reviewed the situation in a paper [2] following that of Woodruff and Erdmann [3] on "endomixis" in *Paramecium.*

[2] Calkins, G. N., Cycles and rhythms and the problem of "Immortality" in Paramecium, *Am. Naturalist* (1915), 49, 65.

[3] Woodruff, L. L., and Erdmann, Rhoda, A normal periodic reorganization process without cell fusion in Paramecium, *Journ. Exp. Zoöl.* (1914), 17, 425. Erdmann, Rhoda, and Woodruff, L. L., The periodic reorganization process in Paramæcium caudatum, ibid. (1916), 20, 59.

Without entering into the details of this most interesting controversy, it may be said that there is abundant reason to believe that protozoa undergo physiological old age in common with other animals. The waning vitality, which accompanies this phenomenon, is restored and the animal rejuvenated by a process of fertilization, or, as it is frequently called, syngamy, which is probably of universal occurrence among the Protozoa. Fundamentally it seems to make little difference whether this process is one of autogamy, endogamy, exogamy, endomixis, or parthenogenesis. In every case the need for fertilization asserts itself ultimately and is met in some fashion, primitive or complex, and forms a most interesting stage in the life cycle of the protozoön. It should be borne in mind, however, that endomixis is merely a process of nuclear reorganization unaccompanied by synkaryon formation.

These, then, constitute the facts that are *collectively known as the life cycle.*

The study of the Protozoa is, therefore, seen to involve a study of morphology, physiology, and cytology with all their ramifications, which has led Calkins[4] to define protozoölogy—

> as that branch of the biological sciences which deals with the application of biological problems to, and with search for their solution in, the lowest group of animal organisms—the Protozoa.

The literature on the Protozoa is vast and is scattered through many publications. There are several textbooks and innumerable papers and monographs. The literature is found in the journals of zoölogy, botany, medicine, sanitation and hygiene, pathology and bacteriology, physiology and pharmacology, chemistry, genetics, anatomy, and occasionally in other scientific and semiscientific journals. At the end of this paper is appended a short list of some of the standard works on protozoölogy, which will be of aid to the student in the identification of species hitherto unreported in the Philippine Islands. No extended study of the world distribution of the Protozoa has been as yet undertaken, but for the most part they seem quite cosmopolitan, and I have found few fresh-water protozoa in the Philippines that were not familiar to me in the United States.

Collection.—The amateur collector will probably make his studies on forms collected at random. Really systematic work, however, entails a study of the ecology of the protozoa sought and a knowledge of the physical and chemical conditions in the

[4] Calkins, G. N., The scope of protozoology, *Science* (1911), n. s. 34, 129.

environment in which they live. A recent paper by Hausmann [5] contains some excellent hints for collecting and studying fresh-water protozoa. Directions for collecting rhizopods are given by Leidy [6] in his great monograph, but are not so detailed as those given by Hausmann.

Material collected from natural sources should be studied as soon after collection as possible, especially if an enumerative study is to be made. Frequently striking morphological changes manifest themselves after protozoa have been transferred from their natural environment to artificial culture media, and studies of morphology and physiology made in artificial media should be carefully controlled and interpreted with great caution.

Cultivation.—In principle the successful cultivation of protozoa involves the discovery of the kind of food upon which the organism subsists and then supplying it with that food. This is often easier said than done. In the case of the parasitic forms the problem is particularly difficult; and many of them, especially the tissue-dwelling forms, have not yet been cultivated. As to nutrition the free-living forms may be holozoic, holophytic, or saprozoic. A given species may at one time be nourished by the holophytic method and later by the saprozoic; or nutrition in another may at one time be holozoic and at another saprozoic. Lauterborn [7] has applied the term "sapropelic" to a characteristic fauna living under conditions of saprozoic and partly holozoic nutrition. These forms are found in fresh-water mud or ooze composed largely of the decaying remains of dead plants and similar débris. There are many predacious forms that feed wholly on other protozoa, and that must be distinguished from those that live on bacteria. Many of these predatory forms feed on some particular species and apparently select their food with great care. For instance, *Didinium nasutum* lives on *Paramecium; Spathidium spathula,* on *Colpidium colpoda; Actinobolus radians,* on *Halteria grandinella,* and so on. In the absence of the species that furnishes them with food they will quickly starve or encyst.

A large variety of fresh-water forms will live well in hay-infusion media. This may be prepared by boiling 1 gram of

[5] Hausmann, L. A., Observations on the ecology of the Protozoa, *Am. Naturalist* (1917), 51, 157.

[6] Leidy, Joseph, The Fresh Water Rhizopods of North America. Repts. U. S. Geol. Surv. of the Territories. Government Printing Office, Washington, D. C. (1879), 12, 8.

[7] Lauterborn, R., Die "sapropelische" Lebewelt, *Zool. Anz.*, Leipzig (1901), 24, 50.

timothy hay in 100 cubic centimeters of tap water for ten minutes, allowing it to stand uncovered for from twelve to twenty-four hours to allow for the growth of bacteria. Care must be taken that the water does not contain hypochloride of lime or any of the algicides. Pond or well water may be substituted. Distilled water is poor in oxygen, and in fact that constitutes a strong objection to boiled infusions, which likewise tend to become overgrown with bacteria that exert a deleterious effect on the protozoa. An interesting and suggestive paper on this subject has been recently written by La Rue.[8] He makes his medium of sterile timothy hay and filtered tap water. The hay is made into small compact bundles, which are tightly wrapped in several layers of cheese cloth. The bundles are sterilized at from 15 to 17 pounds' pressure in the autoclave for fifteen minutes or more and then dried. This sterilization is intended mainly to kill encysted protozoa. It does not kill all bacteria. The tap water is filtered through filter paper into sterile containers, which should have the effect of removing many of the larger protozoa. It is my experience, however, that most of the smaller forms pass readily through filter paper. La Rue makes up his medium in the proportion of 10 grams of the sterile hay to 2 liters of the filtered tap water. These proportions, the author says, may be considerably varied. The original level of the fluid should be marked and maintained by the addition of filtered tap water from time to time. One or 2 grams of sterile hay may be added each week.

A refinement in the methods of cultivating free-living protozoa has been introduced by Hargitt and Fray [9] in their method for sterilizing *Paramecium* and cultivating it with known strains of bacteria. Their paper is of great interest and significance in connection with experimental work, but the method is too difficult of application and, indeed, is not intended by the authors to apply to the maintenance of ordinary laboratory cultures. The principles brought out, however, are of interest to all workers who are dealing with the problems of the cultivation of protozoa.

Cultures of protozoa have been classified by Williams as being of three types:

Mixed cultures.—Those that contain the "omnium gatherum"

[8] La Rue, G. B., Notes on the culturing of microscopic organisms for the zoölogical laboratory, *Trans. Am. Micros. Soc.* (1917), 36, 163.

[9] Hargitt, G. T., and Fray, W. W., The growth of Paramecium in pure cultures of bacteria, *Journ. Exp. Zoöl.* (1917), 22, 421.

of pond or tap water; a heterogeneous mixture of protozoan, bacterial, and fungoid organisms mixed with lower metazoan forms such as Rotifera, Crustacea, and so forth. In such cultures a complex series of reactions can be generally observed accompanied by cyclic changes in the floral and faunal composition of the culture.

Pure mixed cultures.—These involve the cultivation of one species of protozoa in association with a pure strain of one other microörganism, such as a bacterium or some other protozoön. Although this is frequently referred to as a condition of symbiosis, such is not the case, for the associated organism serves as a source of food for the protozoön.

Pure cultures.—These are cultures of protozoa grown on a medium containing no other organism. The technic involved in the construction and maintenance of such cultures necessitates a close attention to conditions of asepsis and the employment of the methods of the bacteriologist.

Transitional between the last two methods may be said to be that by which certain protozoa may be grown in media sown with killed bacteria.

A great impetus was given to work with the parasitic protozoa through the introduction in 1903 by Novy and MacNeal [10] of bacteriological methods in the cultivation of parasitic protozoa. The general tendency among protozoölogists to-day is to adapt the methods of the bacteriologist to the cultivation of free-living as well as parasitic protozoa. The strange thing about the whole affair lies in the neglect to do this to a greater extent in the past.

It would require too much space to detail the various methods for cultivating protozoa in a paper such as this. So far as may be possible, methods for cultivating individual species will be given in connection with the descriptions that will follow.

Study of the living organism.—A moderate degree of familiarity with the use of the microscope is presupposed in studies of this kind. The relatively quiescent forms such as the Sarcodina, sessile flagellates (Mastigophora), Sporozoa, and Suctoria (Infusoria) are kept in the microscopic field with comparative ease, particularly if the observer is using a mechanical stage. Actively moving flagellates and ciliates are often very

[10] Novy, F. G., and MacNeal, W. J., On the cultivation of Trypanosoma lewisi. Contribution to medical research, dedicated to V. C. Vaughan. Ann Arbor, Mich. (1903), 549.

difficult to manage, for their vigorous movements usually carry them out of range of vision before one can focus on them and make out details of their structure. In such cases some colloid substance that will not harm the organism may be added to the medium. This has the effect of slowing their movements, though their cilia or flagella will continue to vibrate.

Among the substances that have been successfully employed are solutions of cherry tree gum or quince seeds, agar-agar, or carragheen. The latter substance may be obtained at any pharmacy. It is a dried and bleached seaweed, which consists mainly of *Chondrus crispus,* to which is added a small amount of *Gigartina mamillosa.* The substance is soaked in water, until it is converted into a slimy colloid mass. Small amounts may be introduced under the cover glass. Carragheen may be also added to the general culture, but it should be first washed in a 0.5 to 1 per cent solution of sodium bicarbonate. Remove the undissolved pieces at the end of a week or ten days. Change the water in the culture at the end of three or four weeks. *Paramecium* will live for months in such a medium. In the absence of other material gum arabic, gum tragacanth, or the like may be used. A solution of 3 grams of gelatin in 100 cubic centimeters of water gives good results.

On general principles morphological studies should be made in a medium as closely approximating that of the natural environment of the animal as possible. Parasitic organisms should be studied in the normal body fluid in which they occur. Use physiological salt solution and similar media with caution; they may or may not be isotonic to the species under observation. Failure to observe this caution may lead the worker to study and describe distorted instead of normal cells.

Motile organs, such as flagella and cilia, are often difficult to see in the living cell. In such cases one may use a drop or two of a strong solution of tannin or a bare trace of an alcoholic solution of sulphurous acid added to a watchglassful of medium containing the organisms. After the living organisms have been studied, a drop of weak solution of iodine and potassium iodide may be run under the cover glass, which will have the effect of bringing out the cilia and flagella and, frequently, many other parts.

Weak solutions of methyl green slightly acidulated with acetic acid often bring out important structures, particularly the nucleus. The acetic acid will generally cause the discharge of the trichocysts in such forms that possess them.

The gastric vacuoles may be studied in the living organism with very dilute solutions of neutral red or alizarin, added in small quantity to the medium containing the organisms. In connection with the use of intra vitam stains, it should not be expected that they will stain living protoplasm.

Occasionally, interesting results are obtained by adding an opaque material to the culture medium, which will have the effect of causing the organisms to stand out as bright, shining objects on a dark field. This affords an excellent method of studying the action of motile organs. Aniline black is one of a number of the aniline dyes that may be used for this purpose; diphenylamin blue is another. India ink has been used by many workers; it admits of observation of the discharge of the contractile vacuole. Avoid the presence of acid in cultures so treated. These substances may be used in combination with the immobilizing media previously mentioned.

Fixation and staining.—Though a study of the living animal under normal conditions should always precede a study of fixed and stained cells, it must be well borne in mind that staining brings out many important details that cannot be observed in the living cell. The nucleus, the form and finer structure of which is subject to considerable variation in the Protozoa, is seldom visible in any detail in the living cell. The technical treatment of the protozoan cell is not a simple matter. There are a multitude of methods that have been devised to meet special conditions, and it is, of course, impossible to go into this subject in any detail here. I shall be glad to correspond with any investigator who desires aid in connection with any special problem. A general method, which may be applied to the usual run of free-living and parasitic species, is given below.

To secure a good microscopical picture of the animal, the most approved cytological methods must be employed. With the exception of studies of the hæmatozoa, all staining must be done by the "wet method;" that is to say, the preparation must never be allowed to dry until it is sealed under the cover glass. Even with the blood parasites special "wet methods" have been devised that give infinitely better results from the cytological viewpoint than the old Romanowsky methods.

The best general fixative is sublimate-acetic fluid. It is made up as follows:

Saturated solution of mercuric chloride in sea water (per cent)	95
Glacial acetic acid (per cent)	5

A good general stain, which often gives an excellent cytoplasmic effect in addition to the nuclear stain, is the formula of Delafield, which is compounded thus:

Hæmatoxylin crystals (grams)	4
Ethyl alcohol, 95 per cent (cc.)	25
Saturated aqueous solution of ammonia alum (cc.)	400

Dissolve the hæmatoxylin in the alcohol and add it to the alum solution. Allow the mixture to ripen in the light in a bottle lightly stoppered with cotton. At the end of three or four days filter the solution and add:

Glycerin (cc.)	100
Methyl alcohol (cc.)	100

This solution should be allowed to ripen further for four or five weeks before using. It keeps well, but has a tendency to redden in the course of time. When this occurs, add a small amount of 1 per cent alum solution or a crystal or two of alum. The stain is best used in dilute solution, for it is very powerful and penetrating.

A useful formula is one that I have used extensively for many years as have several of my colleagues. This stain should be made up as follows:

Concentrated Delafield's hæmatoxylin (cc.)	10
Distilled water (cc.)	90
Glacial acetic acid (cc.)	0.5 to 1
Chloral hydrate crystal (gram)	0.5

Staining may be done with this mixture by either the progressive or the regressive method. It often gives a good flagellum stain by the progressive method. I have obtained some fine preparations of the malarial parasite by prolonged staining in the mixture.

The carmine stains often give brilliant results, especially if used after mercury fixation. Simple borax carmine or the picrocarmine of Hoyer, Ranvier, or Weigert are to be recommended, although I have secured my best results with Hoyer's formula. When staining by the regressive method with any of the hæmatoxylin or carmine stains named, differentiation should be carried out in 70 per cent alcohol very slightly acidified with hydrochloric acid.

This, of course, does not exhaust the list of methods that may be employed with the Protozoa. For others the reader must consult the general and special works on the Protozoa.

When protozoa are very abundant in a culture their collection and staining is a relatively simple matter. Under such conditions

I make use of what is called the round-bottom-vial method. Vials of from 5 to 8 cubic centimeters' capacity may be used. They should be filled to about two-thirds of their capacity with the fixing fluid, and material from a rich part of the culture should be transferred to them with a pipette. The organisms are instantly killed and fixed. When they have settled to the bottom of the vial, the supernatant fluid should be decanted or cautiously drawn off with a pipette, leaving the fixed organisms in a mass in the bottom of the vial. Alcohol of 70 per cent strength should be added, and when the organisms have again settled, this should be withdrawn and 95 per cent alcohol substituted. The organisms are allowed to settle once more. Keep the vial corked, especially in wet weather, to avoid absorption of water by the alcohol.

Slides are prepared by lightly smearing a little Mayer's albumen fixative over an area at the center of the slide about the size of a 5-centavo piece. This is made up by adding an equal quantity of glycerin to the white of egg, which has been previously well beaten. Add 1 gram of sodium salicylate to each 50 cubic centimeters of the mixture as a preservative. Mix and filter carefully before using.

A small quantity of the sediment from the bottom of the vial, together with a *minimum amount* of the alcohol, is then drawn up into a capillary pipette and forcibly spurted on the surface of the albumen film. The slide is then immersed in 95 per cent alcohol contained in a Coplin staining jar. From the time the protozoa are transferred to the slide until the preparation is finally sealed under the cover glass, the slide should never be allowed to dry. If it dries, the preparation is ruined. From the 95 per cent alcohol the slide is transferred to 70 per cent alcohol containing sufficient iodine to color it a port wine shade. It should remain there for ten minutes or possibly longer in order to remove the excess of mercury from the organisms. The iodine should be then washed out in 70 per cent clear alcohol and the slide passed down through 50 per cent alcohol to water by three- to five-minute stages. The preparation is then stained.

After staining, the slide is washed in tap water, is carried into 50 per cent alcohol where it should remain for three to five minutes, and finally is put into 70 per cent alcohol. Differentiation, when required, is carried out at this stage in the acidified 70 per cent alcohol before mentioned, the excess of acid afterward being thoroughly washed out in clear 70 per cent alcohol for at least fifteen minutes. After this the slide is passed through 95 per cent alcohol, 100 per cent alcohol, and xylol, five minutes in each change, and finally mounted in xylol Canada

balsam. The process of staining and differentiation should be carefully watched under the microscope in order that the required structural details may be clearly brought out. Some experience will be necessary to get good results, but if the beginner will observe and profit by his mistakes, he will soon be able to make passably good preparations.

In the case of blood parasites such as trypanosomes, malarial parasites, *Babesia,* and the like regular blood films should be made on a perfectly clean, grease-free slide. The films should be spread so as to avoid crushing the blood elements and the parasites. They should be quickly dried and then fixed for five minutes in absolute methyl alcohol. They may be then stained with Giemsa's solution. I believe that this is the best blood stain we have, but in its absence one may use Wright's, Hastings's, Jenner's, or any of the other standard formulæ. I carry out the process of staining with Giemsa's solution in shallow Petri dishes just large enough to hold the slides. The slides are supported, face down, on each end by a thin piece of glass, and the staining solution is run in between the bottom of the dish and the smeared surface of the slide with a pipette. By using this method the precipitations that tend to form from the blood stains will fall on the surface of the dish instead of being deposited on the slide to perplex the microscopist.

The Giemsa solution should be made up in distilled water, using one drop of the stock staining solution to each cubic centimeter of distilled water. Experience will show how long to stain the preparation. Five or six minutes will generally answer for trypanosomes, if the film be fresh. Fifteen minutes or even longer are required for intracorpuscular parasites. When the slide is stained, wash it quickly in a stream of distilled water, blot lightly with filter paper, and lean the slide up, face inward, until it is thoroughly dry. The preparation may be then mounted in Canada balsam, or it may be examined directly under the oil-immersion objective.

When protozoa are scarce in a culture, or it is desired to collect small surface-dwelling forms, cover glasses may be floated on the surface of the culture overnight and then transferred, face up, to a Syracuse watch glass containing fixing fluid. The process of staining, differentiation, dehydrating, and so forth may be carried on under the microscope in the Syracuse dishes in the same way that the slides were handled in the staining jars.

Individual protozoa of the larger species may be picked out of a watch glass containing them, with a capillary pipette, the operator working under a binocular microscope or Hastings's lens.

This requires a little experience and some knack, which are soon mastered. Investigators desiring to do embedding and sectioning are advised to consult the standard works dealing with those subjects.

In handling rich cultures of the small amœboid forms, such as *Vahlkampfia,* a drop of the medium containing the amœbæ may be placed on the surface of the slide. If the slide be laid aside in a moist chamber for a little while, the organisms will settle on to the glass, extend their pseudopodia, and remain there. The slide may be then immersed in the fixing fluid, when it will be found that the amœbæ will adhere firmly to the slide and will remain there through the subsequent manipulations. Many other small forms will do this—even some of the flagellates—but the larger species, particularly the ciliates, will almost always float off the slide and become lost.

Measuring.—Ideally, measurements should be made of the living organisms, but it is not always possible to do this because of the movements of the organism. The animals should be killed in a fluid that will not shrink, swell, or otherwise alter their form, and they should not be subjected to pressure such as that of the cover glass. Measurements of less than five hundred individuals have no great value. Care should be taken not to measure species outside of those it is desired to study, also to measure individuals in the same phase of the life cycle. In measuring small forms fixed on the slide, select only those that lie perfectly parallel with the surface of the slide—that is to say, do not measure the animal unless its entire surface is in perfect focus at one time.

Jennings [11] uses Worcester's fluid (saturated solution of mercuric chloride in 10 per cent formol, 9 parts; acetic acid, 1 part) or a chrome-osmic fluid made up in the proportion of 1 per cent osmic acid in 1 per cent chromic acid for killing and fixation. The animals are brought in a drop of fluid medium into a Syracuse watch glass and immediately overwhelmed with a large volume of the killing fluid. A portion of the fluid is then removed with a pipette, and 25 per cent glycerin is added, in which the cells are kept until they have been measured. The actual measurement is made with an Edinger drawing and projection apparatus. The organisms are transferred to a thin slide on a flat drop of the glycerin without a cover. They are then projected on to a drawing board and drawn and measured with

[11] Jennings, H. S., Assortative mating, variability and inheritance of size, in the conjugation of Paramecium, *Journ. Exp. Zoöl.* (1911), 2, 1.

a millimeter rule to a predetermined scale. By using a magnification of 500 diameters, each millimeter of the rule corresponds to 2 μ (0.002 millimeter).

In lieu of this, the organisms may be measured directly under the microscope by employing a stage micrometer and micrometer ocular; or they may be projected on to paper and drawn with the aid of a camera lucida.

This series of papers is designed to form the basis of a census of the Protozoa of the Philippine Islands and will, of course, deal with parasitic as well as free-living species. It is a task that at best will consume many years and certainly cannot be completed within the span of one man's life. I must, to a large extent, fall back upon the assistance of others, such as my colleagues, students, and other volunteer workers. Already I am indebted to several friends for reporting species that had not come under my notice. It is planned to acknowledge all such reports in this series. Such surveys have been made in many other places, generally under State support, and their value scarcely needs to be touched upon. The intimate relations of the Protozoa to problems in general biology, medicine, veterinary medicine, geology, physiology, pharmacology, and other sciences, as well as their importance as ultimate sources of food supply, has been so often pointed out that it is superfluous to make mention of them here.

There are at present no facilities in Manila for making studies of the marine forms found in neighboring waters, save some of the more easily obtainable plankton forms; therefore a study of the local Foraminifera [12] and Radiolaria will probably have to be indefinitely deferred.

The system of classification that will be followed is that set forth by Calkins.[13] It has occurred to me to introduce some changes in classification and nomenclature made desirable through recent progress in the science, such as the abolition of the genus *Leishmania* and the incorporation of the organisms included within it in the older genus *Herpetomonas*, where it seems to belong; or the removal of the genus *Plasmodium* from the Hæmosporidia to the Coccidiida. Several changes are suggested in the Infusoria, particularly among the Hypotrichida,

[12] Cushman [*Proc. U. S. Nat. Mus.* (1911), 38, No. 1759] has made a study of a few species of arenaceous Foraminifera found in Philippine waters, in connection with the work of the Albatross Expedition of 1907–1910.

[13] Calkins, G. N., Protozoölogy. Lea & Febiger, Philadelphia (1909).

and also some among the Rhizopoda, but pressure of other duties and lack of space make it seem undesirable to take up those matters here, so Calkins's classification will be adhered to throughout.

Many schemes of classification have been proposed for the Protozoa, and nearly every author of prominence has adopted a plan to meet his own ideas. The best of these systems have as their basis the organs of locomotion and their modifications. These define the principal groups or subphyla, further grouping being carried out on the basis of other characteristics. Under the system of Calkins, the phylum Protozoa is divided into four subphyla (classes of Minchin) : the Sarcodina, or protozoa having pseudopodia as organs of locomotion; the Mastigophora, whose motile organs consist of flagella; the Sporozoa, having no special organs of locomotion in the trophic stages; and the Infusoria, having motile organs in the form of cilia. These groups will be further defined later on.

SUBPHYLA OF THE PROTOZOA

SARCODINA.—Protozoa having motile organs in the form of changeable protoplasmic processes known as pseudopodia. These may be either simple or supported by a central axial filament (p. 194).

MASTIGOPHORA.—Protozoa having motile organs in the form of one or more vibratile or undulating processes known as flagella (p. 199).

SPOROZOA.—Exclusively parasitic protozoa, reproducing mainly by spore formation (p. 203).

INFUSORIA.—Protozoa having motile organs in the form of flexible, vibratile protoplasmic processes known as cilia. These may be modified to form cirri, membranes, and membranelles. Dimorphic nuclei (macro- and micronuclei). Some forms are provided with tentacles in the adult stage (p. 208).

TABULAR VIEW OF THE CLASSIFICATION OF THE PROTOZOA

Subphylum SARCODINA (p. 194).
- Class RHIZOPODA (p. 195).
  - Subclass Proteomyxa (p. 195).
    - Genus Plasmodiophora.
      - Vampyrella.
      - Nuclearia.
  - Subclass Mycetozoa (p. 195).
    - Order Acrasiæ (p. 195).
      - Filoplasmodia (p. 195).
      - Myxomycetes (p. 195).
  - Subclass Foraminifera (p. 195).
    - Order Gromiida (p. 195).
      - Astrorhizida (p. 195).
      - Lituolida (p. 195).
      - Miliolida (p. 196).

CHARACTERS OF THE HIGHER GROUPS OF THE PROTOZOA

Subphylum **SARCODINA.**—Protozoa having motile organs in the form of changeable protoplasmic processes known as pseudopodia. These may be either simple or supported by a central rod of stiffened protoplasm,

Subphylum **SARCODINA**—Continued.

the axial filament. They range in form from those that are little more than minute masses of protoplasm to forms having elaborate shells, tests, and skeletal structures. They have no affiliations with the bacteria.

Class **Rhizopoda.**—The pseudopodia have no axial filaments and may be lobose, filose, or reticulose.

Subclass **Proteomyxa.**—Minute forms having soft, miscible pseudopodia. These anastomose when in contact with each other. Plasmodium formation may occur. This subclass includes many parasitic forms. Typical genus, *Plasmodiophora* Woronin, 1878.

Subclass **Mycetozoa.**—Single cells having pseudopodia. These frequently fuse to form complex plasmodia. This group is claimed by the botanists because of the fungi characteristics shown.

Order **Acrasiæ.**—A pseudoplasmodium is formed through the union of the single cells. The cells do not fuse. This results in the formation of a plasmodium inclosed in a gelatinous mantle. Typical genus, *Copromyxa* Zopf, 1885.

Order **Filoplasmodia.**—There is no firm union of the cells. The connection is maintained by delicate protoplasmic threads. Typical genus, *Labyrinthula* Cienkowsky, 1876.

Order **Myxomycetes.**—The cells are completely aggregated. This often leads to the formation of complex fructifications in which the spores, which are frequently flagellated, are scattered by the aid of hygroscopic threads. Typical genus, *Fuligo* Haller, 1768.

Subclass **Foraminifera.**—The classification here follows that of Lister (1903). The classification of this group is very difficult, it being possible to place some genera under the order Testacea with perfect propriety. The pseudopodia are fine, branching, and frequently anastomose. The shells may be chitinous, calcareous, siliceous, gelatinous, or arenaceous; frequently they are very complex. The Foraminifera includes a large number of marine forms, some of them pelagic, others abyssal. Many creep about the surface, while some are sedentary. The shells may have many pores (Perforina), or may be without pores (Imperforina). They may be single-chambered (Monothalamous) or consist of many chambers (Polythalamous).

Order **Gromiida.**—The shells are single-chambered, chitinous, and generally without calcareous deposit. Simple in structure. Does not include the fresh-water testate forms. Typical genus, *Gromia* Dujardim, 1835.

Order **Astrorhizida.**—Arenaceous shells formed of particles of sand, mud, sponge spicules, etc., built up on a chitin base. The test is monothalamous, composite, and large. Lister groups four families under this order. Typical genus, *Astrorhiza* Sandahl, 1857.

Order **Lituolida.**—Arenaceous shells which are usually regular, mono- or polythalamous. According to Lister it comprises sandy isomorphs of hyaline or porcellaneous forms. Lister recognizes four families. Typical genus, *Lituola* Lamarck, 1801.

Subphylum **SARCODINA**—Continued.

Class **Rhizopoda**—Continued.

Subclass **Foraminifera**—Continued.

Order **Miliolida.**—Shells are calcareous and hyaline. They may be covered with sand or detritus. Lister notes six families. Typical genus, *Peneroplis* Montfort, 1810.

Order **Textularida.**—Arenaceous forms with or without perforated calcareous base. The chambers are arranged in one or two series. These may be irregular, alternate, or spiral. Three families. Typical genus, *Textularia* Defrance, 1824.

Order **Chilostomellida.**—Finely perforated polythalamous calcareous tests. Lister names three genera. Typical genus, *Chilostomella* Reuss, 1860.

Order **Lagenida.**—The tests are similar to those of the Chilostomellida save for the monothalamous shell. However, this may be compounded by the union of chambers end to end in a straight or curved series. There are no canals and no canalicular skeleton. Four families. Typical genus, *Nodosaria* Lamarck, 1801.

Order **Globigerinida.**—Calcareous perforated tests. The few chambers are spirally arranged. No canals or canal systems. No division to families. Typical genus, *Globigerina* D'Orbigney, 1826.

Order **Rotalida.**—Calcareous perforated tests. Chambers are arranged in a spiral and all are visible from one aspect. The more highly developed forms have a canal system in some cases. Three families. Typical genus, *Rotalia* Lamarck, 1801.

Order **Nummulitida.**—Tests are bilaterally symmetrical (except in *Amphistegina*), calcareous, and filled with tubules. Canal system in the higher forms. Three families. Typical genus, *Polystomella* Lamarck, 1822.

Subclass **Amebea.**—Characteristic amœboid forms, naked or testate. This subclass includes the most familiar rhizopods and notably those occurring as parasites of man. The pseudopodia are blunt or lobose and do not form anastomoses.

Order **Gymnamebida.**—The body is naked, though some forms show a hardening or condensation of the cortical plasm to form a membranelike envelope. This order includes several genera, among them being *Amœba, Entamœba,* etc., and, provisionally, *Neuroryctes.*

Order **Testacea** (Thecamebida).—The organism is amœboid but is invested with a definite membrane or test. This may be composed of a variety of substances cemented to a chitinous base. There is a single opening to the shell through which the pseudopodia are protruded. Typical genus, *Euglypha* Dujardin, 1841.

Class **Actinopoda.**—The pseudopodia are fine, raylike, and supported by a central axial filament of stiffened protoplasm, which may be extended from, or withdrawn into, the body. These rods are in close relation to the nucleus or nuclei and probably correspond to the kinetic element in the flagellum seen in the Mastigophora.

Subphylum **SARCODINA**—Continued.

Class **Actinopoda**—Continued.

Subclass **Heliozca.**—Mainly inhabitants of fresh water, few marine forms being known. They are characterized by the absence of a central chitinous capsule between the endo- and ectoplasm.

Order **Aphrothoraca.**—These forms are naked except during encystment. Typical genus, *Actinosphærium* Stein, 1857.

Order **Chlamydophora.**—The animal is invested with a felted fibrous or soft gelatinous covering. Typical genus, *Heterophrys* Archer, 1865.

Order **Chalarathoraca.**—The covering is siliceous and is made up of loosely connected or separate spicules. Typical genus, *Acanthocystis* Carter, 1863.

Order **Desmothoraca.**—The covering is of one piece and is perforated by numerous openings. Typical genus, *Clathrulina* Cienkowsky, 1867.

Subclass **Radiolaria.**—These forms are characterized by the presence of a firm chitinous capsule separating the endo- and ectoplasm. This capsule is perforated in different ways for communication between the inner and outer plasm. Exclusively marine forms, pelagic or suspended at various depths. Some are abyssal. This classification is based on Haeckel's Challenger monograph.

Division A. **Porulosa.**—Spherical forms. The central capsule is spherical and is perforated by numerous minute pores.

Legion 1. **Peripylea** (Spumellaria).—The pores in the central capsule are evenly scattered. A skeleton usually is present; it is composed of scattered or fused spicules or of a latticed network.

Order **Collida** (Brandt).—With or without skeletogenous spicules. Solitary forms. Typical genus, *Thalassicolla* Huxley, 1851.

Order **Spherozœa** (Brandt).—Colonial forms. With or without skeletogenous spicules. Typical genus, *Collozoum* Haeckel, 1862.

Order **Spheroida.**—The skeleton occurs as one or several concentric spherical, latticed, or reticulate structures. Typical genus, *Actinomma* Haeckel, 1862.

Order **Prunoida.**—Characterized by spheroidal, ellipsoidal to cylindrical skeleton, single or concentric, occasionally constricted. Haeckel names seven families. Typical genus, *Druppula* Haeckel, 1887.

Order **Discoida.**—With discoidal to lenticular skeletons and central capsules. Haeckel names six families. Typical genus, *Cenodiscus* Haeckel, 1887.

Order **Larcoida.**—The skeleton, which is ellipsoidal with asymmetrical axes, forms almost a spiral in some cases. Haeckel names nine families. Typical genus, *Pylonium* Haeckel, 1881.

Order **Spheropylida** (Dreyer).—In addition to the usual distributed pores, there is one basal, or a basal and an apical opening to the central capsule. Typical genus, *Spheropyla* Dreyer, 1888.

Subphylum **SARCODINA**—Continued.
Class **Actinopoda**—Continued.
Subclass **Radiolaria**—Continued.
Division A. **Porulosa**—Continued.

Legion 2. **Actipylea** (Acantharia).—Here the pores are aggregated in definite areas. The skeleton consists, usually, of twenty spines of acanthin (strontium sulphate), which radiate from the center of the organism in a regular order (Mullerian law). These spines may branch to form a latticed shell.

Order **Actinellida**.—There are more than twenty radial spines. Haeckel names three families. Typical genus, *Xiphacantha* Haeckel, 1862.

Order **Acanthonida**.—The twenty spines are all equal in size and are arranged in regular order: four equatorial, eight tropical, and eight polar. Haeckel names three families. Typical genus, *Acanthrometron* Müller, 1855.

Order **Spherophracta**.—A complete fenestrated shell. Twenty equal, quadrangular spines. Haeckel names three families. Typical genus, *Drataspis* Haeckel, 1860.

Order **Prunophracta**.—An ellipsoidal, lenticular, or doubly conical shell is present. The twenty radial spines are unequal. Haeckel names three families. Typical genus, *Thoracaspis* Haeckel, 1860.

Division B. **Osculosa**.—The form is monaxonic. The pores of the central capsule are limited to an area on the base, or to one such primary basal area and two secondary apical areas. These perforated areas of the central capsule are termed oscula.

Legion 3. **Monopylea** (Nassellaria).—The skeleton is siliceous. The central capsule consists of a single layer of chitin; it is subspherical to ovoid and is perforated at one pole only.

Order **Nassoida**.—The skeleton is absent. Haeckel names one family. Typical genus, *Nassella* Haeckel, 1887.

Order **Plectoida**.—The skeleton is formed of three or more spines, which radiate from one point below the central capsule or from a central rod. Members of this order never form a complete latticed skeleton. Haeckel names two families. Typical genus, *Triplecta* Haeckel, 1881.

Order **Spyroida**.—A lower chamber may be added to the shell. The skeleton consists of a sagittal ring and a latticed shell that is furrowed in the sagittal plane. Haeckel names four families. Typical genus, *Dictyospiris* Ehrenberg, 1847.

Order **Stephoida**.—The spines fuse to form one or more rings, which compose the skeleton. Haeckel names four families. Typical genus, *Lithocircus* Müller, 1856.

Order **Botryoida**.—The skeletons are similar to those in the order Stephoida, but they have, in addition, another wing-like process or lobe and one or more additional chambers. Haeckel names three families. Typical genus, *Lithobotrys* Ehrenberg, 1844.

Order **Cyrtoida**.—The skeletons lack the lobes or furrows, but are in other respects similar to those in the order Botryoida. Haeckel names twelve families. Typical genus, *Theoconus* Haeckel, 1887.

Subphylum **SARCODINA**—Continued.
Class **Actinopoda**—Continued.
Subclass **Radiolaria**—Continued.
Division B. **Osculosa**—Continued.

Legion 4. **Cannopylea** (Pheodaria).—The skeleton is siliceous, the spicules or bars often being hollow. There is a double central capsule of chitin, which has a spoutlike main opening at one pole and frequently one or more accessory openings at the opposite pole. Dark pigment granules, spoken of as *pheodium*, are found in the extracapsular protoplasm.

Order **Pheocystina**.—The skeleton may be absent. When it is present, it consists of distinct spicules. The central capsule lies in the center of the body, which is spherical. Haeckel names three families. Typical genus, *Aulactinium* Haeckel, 1887.

Order **Pheospheria**.—The skeleton is a simple- or double-latticed sphere. The central capsule occurs in the geometrical center of the body. Haeckel names four families. Typical genus, *Oroscena* Haeckel, 1887.

Order **Pheogromia**.—The central capsule is excentric, lying in the aboral half of the cell. The skeleton is composed of a simple latticed shell, which has a large opening at one pole. Haeckel names five families. Typical genus, *Pharyngella* Haeckel, 1887.

Order **Pheoconchia**.—The skeleton is characterized by the presence of two valves, which open in the same plane as the three openings of the central capsule. Haeckel names three families. Typical genus, *Concharium* Haeckel, 1879.

Subphylum **MASTIGOPHORA**.—Protozoa having motile organs in the form of one or more vibratile or undulating processes known as flagella. These are in relation to bodies of nuclear or centrosomic nature such as the kinetonucleus or the blepharoplast,[14] which may lie free in the cytoplasm or inside of the nucleus. Forms found in the orders Trypanosomatida and Polymastigida may have undulating membranes of a kinetic nature, bordered by a flagellum. Many species show marked plant characteristics, and some of the more primitive forms are closely allied to the bacteria.

Class **Zoömastigophora**.—Mastigophora having predominant animal characteristics.

Subclass **Lissoflagellata**.—Lacking protoplasmic collars and having "smooth" bodies.

[14] Minchin regards the blepharoplast as "a centrosome which is in relation to a motor cell-organ." It is not to be regarded as a kinetonucleus any more than the latter is to be looked upon as the equivalent of the micronucleus of the Infusoria. Swezy [*Univ. Calif. Pub. Zoöl.* (1916), **16**, 185] has recently discussed the kinetonucleus in relation to Hartmann's Binucleata and the parabasal body of the Polymastigida. Kofoid and McCulloch [*Univ. Calif. Pub. Zoöl.* (1916), **16**, 113] regard the kinetonucleus as in reality the parabasal body or kinetic reservoir, which fluctuates in the volume of its substance with the changing internal conditions and motor activities of the organism.—F. G. H.

Subphylum **MASTIGOPHORA**—Continued.

Class **Zoömastigophora**—Continued.

Subclass **Lissoflagellata**—Continued.

Order **Spirochætida.**—The systematic position of this group is still unsettled, and they are grouped with the flagellates largely as a matter of convenience. The tendency is to place them in a group intermediate between the Protozoa and the Bacteria. However, that question cannot be entered into here. These organisms have spiral, *flexible*, somewhat plastic bodies, through which the chromatin is distributed in the form of granules, or blocks, or possibly as a helix. Some forms are described as having a crista or nonkinetic membrane running along the body and superficially resembling the undulating membrane of the trypanosomes, to which, however, it is not analogous. Transverse and longitudinal division is described. Other writers describe a multiple transverse division (granule formation) or the formation of coccoid bodies. Life histories are very incomplete. The order includes many parasitic species, some of which are highly pathogenic. Others are free-living. Typical genera: *Spirochæta, Cristispira, Saprospira, Treponema,* and *Leptospira.*

Order **Monadida.**—Mastigophora of the simpler type. The bodies are plastic and sometimes amœboid. One or more flagella occur at the anterior end. Many saprozoic forms. The holozoic forms have no definite mouth opening, the food being driven down to the base of the flagellum and ingested by a specialized area of soft protoplasm at that point.

Family **Rhizomastigidæ.**—The body is amœboid. The pseudopodia may be lobose like the Rhizopoda or axial as in the Actinopoda. There are one or two flagella. The flagella and pseudopodia coöperate in food-taking. Typical genus, *Mastigamœba* Schultze, 1875.

Family **Cercomonadidæ.**—There is no actual pseudopodia formation, but the cells are frequently very plastic and changeable in form. There is one flagellum with a flagellum-fissure at its base. Nutrition is holozoic or saprozoic. The family includes many parasites. Typical genera: *Cercomonas* Dujardin, 1841; *Herpetomonas* Kent, 1880; *Leishmania* Rogers, 1905.

Family **Codonecidæ.**—Minute, colorless "monad" forms. They secrete and remain in membranous or gelatinous cups. Typical genus, *Codoneca* James-Clark, 1866.

Family **Bikecidæ.**—The base is broader than the anterior extremity and bears a tentaclelike process. The individuals are minute and may form colonies. Nutrition is holozoic. Typical genus, *Poteriodendron* Stein, 1878.

Family **Heteromonadidæ.**—Minute, colorless "monads" that, in addition to the principal flagellum, possess one or more accessory flagella. They frequently give rise to beautiful colonies, which form on a common stalk. Typical genus, *Anthophysa* St. Vincent, 1824.

Order **Heteromastigida.**—The distinguishing characteristic of the order is the possession of two or more flagella, one of which is

Subphylum **MASTIGOPHORA**—Continued.
Class **Zoömastigophora**—Continued.
Subclass **Lissoflagellata**—Continued.
Order **Heteromastigida**—Continued.

directed forward and the other or others directed downward and backward—the so-called heteromastigote types. The forward flagellum is used in locomotion. The bodies are naked and plastic or provided with a highly differentiated membrane.

Order **Trypanosomatida.**—Exclusively parasitic forms of vertebrates and some invertebrates. Those found in the blood of mammals may have a stage in the life cycle occurring in some arthropod, or an arthropod may be the direct or mechanical transmitter.[15] Trypanosomes of fishes in many instances are transmitted by leeches. These organisms are elongated, usually pointed at each end, and have one or two flagella arising from the kineto- or motor nucleus. There is an undulating membrane, bordered by a flagellum, running from the kinetonucleus at the posterior end to the anterior end, where the flagellum is usually continued as a free lash. This undulating membrane is believed to be supplied with myoneme fibrils. In addition, there is a trophonucleus, which regulates the vegetative functions of the cell. A large group, of which the complete life history is known in no case. Typical genera: *Trypanosoma* Gruby, 1841; *Trypanoplasma* Laveran and Mesnil, 1904.

Order **Polymastigida.**—This order is characterized by species having numerous flagella, which may be arranged in groups. There may be one or many mouth openings, which are usually situated at the bases of the flagella. Some forms possess undulating membranes of a type similar to that seen in ***Trypanosoma.*** These may be bordered internally by a parabasal body. The order includes many parasitic species.

Tribe 1. **Astomea.**—The flagella are numerous and uniformly distributed. There are no special mouth openings. Typical genus, *Multicilia* Cienkowsky, 1881.

Tribe 2. **Monostomea.**—The mouth opens at the base of a group of from three to six flagella. Typical genus, ***Trichomonas*** Donne, 1837.

Tribe 3. **Distomea.**—There are two groups of flagella with a mouth opening at the base of each. Typical genus, *Hexamitus* Dujardin, 1838.

Tribe 4. **Trichonymphinea.**—Parasitic forms found in the digestive tracts of termites. They are covered with a coating of long flagella. There is a stout pyriform organelle, developed apparently in connection with the nucleus, which bears a similarity to the parabasal body of *Trichomonas.* Typical genus, *Trichonympha* Leidy, 1877.

Order **Euglenida.**—Large, free-living forms having one or two flagella. The body is contractile, showing the metabolic or euglenoid movements, with often a complicated body wall. There is a mouth and pharyngeal opening at the base of the flagella, which

[15] It is to be doubted if true trypanosomes ever occur as parasites of non-blood-sucking arthropods.

Subphylum **MASTIGOPHORA**—Continued.

Class **Zoömastigophora**—Continued.

Subclass **Lissoflagellata**—Continued.

Order **Euglenida**—Continued.

is the point of discharge of the contractile vacuole. Some forms possess chromatophores, and colony forms occur.

Family **Euglenidæ**.—These are elongated, more or less pointed, and usually possessed of but one flagellum. Spiral stripings along the body show the course of the myonemes. Green chromatophores and red pigment eyespots or stigmata are usually present, as are pyrenoids and granules of paramylum. Typical genus, *Euglena* Ehrenberg, 1830.

Family **Astasiidæ**.—Body is colorless, elongate, and usually provided with a striped membrane. Eyespots (stigmata) absent. Otherwise they resemble members of the family Euglenidæ. Typical genus, *Astasia* Ehrenberg, 1838.

Family **Peranemidæ**.—Bodies usually symmetrical and either stiff or plastic. Typical genus, *Peranema* Dujardin, 1841.

Order **Silicoflagellida**.—Forms found parasitic on Radiolaria. They are of simple structure, having a peculiar latticelike silica skeleton and one flagellum. Typical genus, *Distephanus* Stöhr, 1881.

Subclass **Choanoflagellata**.—These forms are distinguished by a protoplasmic collar, which surrounds the base of the flagellum, which may be extended from, or withdrawn into, the body. They are simple in structure. Colonies, which are frequently formed, are embedded in a chitinous or gelatinous matrix.

Class **Phytomastigophora**.—Mastigophora, having marked plant characteristics. The class includes many complex colony forms in which there is division of labor and sexual dimorphism. The individual cells composing these colonies are always of simple structure, possessing eyespots, pyrenoids, and chromatophores, which may be brown, yellow, or green.

Subclass **Phytoflagellata**.—The chromatophores are yellow or green.

Order **Chrysoflagellida**.—The chromatophores are yellow. Typical genus, *Synura* Ehrenberg, 1833.

Order **Chloroflagellida**.—The chromatophores are green. Typical genus, *Pleodorina* Shaw, 1894.

Subclass **Dinoflagellata**.—The organisms have an outer shell of cellulose in the form of plates and include many fresh-water and marine species, many of great beauty and some of bizarre form. Two furrows usually cut the body. Of these furrows the transverse is the most important. A flagellum lies in this furrow, while another is directed forward in advance of the organism. These flagella impart a rotation and forward movement at the same time. The organisms contain yellow or brown pigment.

Order **Adinida**.—There are no furrows, the flagella lying free in the water. The transverse flagellum has a movement the same as though the furrow were present. Typical genus, *Prorocentrum* Ehrenberg, 1833.

Order **Diniferida**.—Both longitudinal and transverse furrows are present.

Subphylum **MASTIGOPHORA**—Continued.
Class **Phytomastigophora**—Continued.
Subclass **Dinoflagellata**—Continued.
Order **Diniferida**—Continued.
Family **Peridinidæ**.—The shell may be absent. The transverse furrow is without wide ledges. Typical genus, *Peridinium* Ehrenberg, 1832.
Family **Dinophysidæ**.—The borders of the transverse furrow are developed into great ledges, making a deep furrow for the flagellum. Typical genus, *Triposelenia* Kofoid.
Order **Polydinida**.—This order includes but one genus, *Polykrikos* Bütschli, 1873. It manifests some of the characteristics of members of the subphylum Infusoria in the possession of micro- and macronuclei and nematocysts. The body is naked and has several transverse furrows and flagella.[16]
Subclass **Cystoflagellata**.—Exclusively marine forms including but three genera, *Noctiluca, Leptodiscus,* and *Craspedotella.* The body is highly parenchymatous with a firm membrane. A single nucleus. The young or "embryonic" stages are dinoflagellate. *Craspedotella* resembles a microscopic medusa, having a velumlike membrane on its under surface.

Subphylum **SPOROZOA**.—A group of protozoa, exclusively parasitic. Reproduction is mainly, but not invariably, by spore formation. The term spore formation as used here is to be taken in the broad sense as including asexual spore formation (schizogony) and spore formation following fertilization (sporogony). In a general sense the Sporozoa have no motile organs; but some of them, as the gregarines, are fitted with myonemes, which enable them to move with a vermiform motion. Some of the gametes are flagellated. In the Neosporidia pseudopodium formation occurs in some species. Simple division occurs among the Schizogregarines and forms an exception to the rule regarding spore formation as a characteristic of the subphylum. Members of the group in some instances show affinities with the Sarcodina and in others with the Mastigophora. It cannot be regarded as a stable group from the taxonomic viewpoint. The Gregarinida and the Coccidiida may be looked upon as well-established orders, but the remainder of the group, particularly in regard to the entire class Neosporidia, can, for the present, be regarded only as a catchall for species that cannot be properly placed until their full life histories are known. The classification, therefore, must stand as it is until that time arrives.
Class **Telosporidiá** (Schaudinn).—The life of the individual ends with sporogony.
Order **Gregarinida**.—Reproduction usually confined to spore formation, which follows the union in fertilization of slightly differentiated gametes. Cœlozoic.
Suborder **Schizogregarinæ**.—In addition to spore formation, the individual may reproduce by division or by a process of multiple

[16] Kofoid [*Zool. Anz.* (1907), 31, No. 9–10, 291], in a review of the systematic position of *Polykrikos,* concludes that it is a colonial dinoflagellate of 2, 4, or rarely 8 zoöids. He places it in the subclass Dinoflagellata, family Gymnodinidæ, and subfamily Polydininæ.

Subphylum **SPOROZOA**—Continued.
Class **Telosporidia** (Schaudinn)—Continued.
Order **Gregarinida**—Continued.
Suborder **Schizogregarinæ**—Continued.
budding. Typical genera: *Schizocystis* Lèger, 1900; *Microteniella* Calkins, 1915.

Suborder **Eugregarinæ** (Lèger).—Spore formation apparently is the sole method of reproduction. If division takes place at all, it occurs in the host cell during the "young" stages.

Tribe 1. **Acephalinæ** (Kölliker).—No epimerite is formed. There is no division into chambers. Typical genus, *Monocystis* Stein, 1848.

Tribe 2. **Cephalinæ** (Delage).—An epimerite is present at some stage in the life cycle. There is division of the body by a septum into protomerite and deutomerite. The trophozoites frequently associate in couples arranged tandem-fashion. These individuals are styled the primite and satellite, respectively. Members of this tribe are found parasitic in the digestive tracts of Arthropoda.

Legion A. **Gymnosporea**.—No sporocysts or specially protected sporoblasts are formed, the sporozoites arising directly from the sporoblast mother cells.

Family **Aggregatidæ** (Labbé).—There are a number of residual masses about which the sporozoites are irregularly grouped. Typical genus, *Aggregata* Frenzel, 1885.

Family **Porosporidæ** (Labbé).—There are no protective sporocysts. Special centers (sporoblast centers) of sporozoite formation are present. Typical genus, *Porospora* A. Schneider, 1875.

Legion B. **Angiosporea** (Lèger).—Characterized by well-developed sporocysts. These have an inner and an outer coat, the endospore and epispore, respectively.

Family **Gregarinidæ** (Labbé).—The sporocysts may or may not have sporoducts. The spores are barrel-shaped or oval and in cases where sporoducts are present are united in strings. The trophozoites have a simple epimerite. Typical genus, *Gregarina* Dufour, 1828.

Family **Didymophyidæ** (Lèger).—This family is characterized by the association of the sporonts in pairs. This epimerite of the satellite disappears, which gives the appearance of an organism having three chambers and two nuclei. Typical genus, *Didymophyes* Stein, 1848.

Family **Dactylophoridæ** (Lèger).—The sporocyst opens by simple rupture or by the swelling of the "pseudocyst" or residual mass of plasm. The epimerite is irregular and asymmetrical and is fitted with digitiform processes. Typical genus, *Pterocephalus* A. Schneider, 1887.

Family **Actinocephalidæ** (Lèger).—Sporonts have simple, symmetrical, or irregular appendages and are always solitary. The spores are biconical, cylindrical, or navicular. The cysts open by simple rupture. Found parasitic in the digestive tracts of carnivorous Arthropoda.

Group A. **Sciadiophorinæ** (Labbé).—The protomerite is um-

Subphylum **SPOROZOA**—Continued.
Class **Telosporidia**—Continued.
Order **Gregarinida**—Continued.
Suborder **Eugregarinæ**—Continued.
Tribe 2. **Cephalinæ**—Continued.
Legion B. **Angiosporea**—Continued.
Family **Actinocephalidæ**—Continued.
Group A. **Sciadiophorinæ**—Continued.

brella shaped with radiating ridges. The spores, which are biconical, have central swellings. The epispore opens at the equator by simple dehiscence; the endospore opens terminally. Typical genus, *Sciadiophora* Labbé, 1899.

Group B. **Anthorhynchinæ** (Labbé).—The spores are ovoid and have pointed ends. They are joined in strings. The opening is equatorial. Typical genus, *Anthorhynchus* Labbé, 1899.

Group C. **Pileocephalinæ** (Labbé).—The epimerite is simple and regular; the spores are usually biconical. The cysts open by simple rupture. Typical genus, *Pileocephalus* A. Schneider, 1875.

Group D. **Stictosporinæ** (Labbé).—The spores are biconical, with the points slightly incurved. The endospore bears papillæ. Typical genus, *Stictospora* Lèger, 1893.

Group E. **Actinocephalinæ** (Labbé).—The epimerite always bears appendages. The spores are regular, cylindrical, biconical, navicular, or subnavicular. Typical genus, *Schneideria* Lèger, 1892.

Family **Acanthosporidæ** (Lèger).—The epimerite may be simple or may bear appendages. The sporonts are always solitary. The spores bear bristles at the equator or at the poles. The cysts open by simple rupture. Found parasitic in carnivorous insects. Typical genus, *Corycella* Lèger, 1892.

Family **Menosporidæ** (Lèger).—The epimerite is symmetrical, bears appendages, and is connected with the protomerite by a long neck. The sporonts are solitary. The spores are in the form of more or less curved crescents. The spherical cysts open by simple rupture. Typical genus, *Menospora* Lèger, 1892.

Family **Stylorhynchidæ** (A. Schn.).—Brown- or black-colored spores occurring in strings. The epimerite is symmetrical with or without appendages. The cyst has two envelopes and contains a pseudocyst. Typical genus, *Stylorhynchus* Stein, 1848.

Family **Doliocystidæ** (Labbé).—Septum lacking. The epimerite is regular and simple. The oval spores have a polar thickening. Found parasitic in marine annelida. Typical genus, *Doliocystis* Lèger, 1893.

Order **Coccidiida**.—This order includes a large number of Sporozoa that are cytozoic and karyozoic. The life cycles include an alternation of generations in which a succession of schizogonous cycles gives way to sporogony. Following syngamy, the oösphere gives rise to sporoblasts, which may or may not be covered by a sporocyst membrane and which may develop one or several sporo-

Subphylum **SPOROZOA**—Continued.
Class **Telosporidia**—Continued.
Order **Coccidiida**—Continued.

zoites. In general, the life histories correspond to the life cycle for *Coccidium schubergi* as given by Schaudinn in his classical paper.[17] A group of rare interest.

Suborder **Asporocystinea**.—The sporoblasts form no sporocysts, the sporozoites forming directly from the oösphere.[18]

Family **Eimeridæ** (Asporocystidæ Lèger).—Sporocysts are absent, the sporozoites lying unprotected in the parent cell. Typical species, *Eimeria nova*, parasitic in *Glomeris*.

Suborder **Sporocystinea**.—The sporoblasts are covered by a sporocyst membrane within which the sporozoites are produced.

Family **Isosporidæ** (Disporocystidæ Lèger).—The oösphere gives rise to two sporoblasts with sporocyst coverings. Typical genus, *Isospora* A. Schneider, 1881.

Family **Coccidiidæ** (Tetrasporocystidæ Lèger).—The oösphere gives rise to four sporoblasts with sporocysts. These are the true "Coccidia." Typical genus, *Coccidium* Leuckart, 1879.

Family **Coccidiidæ** (Tetrasporocystidæ Lèger).—The oösphere gives rise to many sporoblasts with sporocysts. Typical genus, *Klossia* A. Schneider, 1875.

Order **Hæmosporidia** (Danilewsky).—An unsettled order including many members whose life histories are imperfectly known. It includes hæmatozoic parasites, cytozoic or cœlozoic in the blood stream of the vertebrate hosts. The affinities of some point to the Mastigophora and of others to the Coccidiida.

Suborder **Acytosporea** (Minchin).—Blood parasites of vertebrates in which the principal stages of the asexual cycle including schizogony are carried out in the host cell or corpuscle. Sporogony is completed in the alimentary tract or body cavity of some blood-sucking arthropod—an insect or arachnid, in the known cases. The parasite of malaria is at present included in this suborder. Typical genera: *Plasmodium* Marchiafava and Celli, 1885; *Babesia* Starcovici, 1893.

Suborder **Hæmosporea** (Minchin).—The Hæmogregarines. They are found parasitic mainly in cold-blooded animals. They are intracellular parasites in the blood, becoming free in the blood stream. There may or may not be an alternation of hosts. Typical genus, *Hæmogregarina* Danilewsky, 1885.

[17] Schaudinn, Fritz, Der Generationswechsel bei Coccidien, *Zoöl. Jahrbücher (Abth. f. Anat.)* (1900), 13, 197. Fritz Schaudinn's Arbeiten. Leopold Voss, Hamburg und Leipzig (1911), 208.

[18] It is probably only a matter of a short time before the genus *Plasmodium* will be removed from the order Hæmosporidia and placed in this group, where it obviously seems to belong. Franca [Journ. de Sciences Matematicas, Fisicas e Naturais, Ser. 3, No. 1 (1917), Lisbon: Imprensa Nacional; cited in *Trop. Vet. Bull.* (1917), 5, 231] has recently taken a definite step in this direction. He makes the Coccidia and Hæmosporidia suborders of the order Coccidiomorpha (Coccidiida) and breaks the Hæmosporidia up into four families: the Hæmogregarinidæ, the Plasmodidæ, the Piroplasmidæ, and the Toxoplasmidæ.

Subphylum **SPOROZOA**—Continued.

Class **Neosporidia** (Schaudinn).—These are parasites principally of vertebrate hosts, mainly fish, which lead a cytozoic, histozoic, or cœlozoic life. Unlike the Telosporidia, spore formation does not end the life of the individual. Instead, sporulation of the parasites, which are amœboid, takes place during the activity of the parent cell and does not interfere with the vegetative processes. Pansporoblast formation is of frequent occurrence.

Order **Myxosporidia** (Bütschli).—The individuals are relatively large and reproduce by pansporoblast formation. The spores are provided with polar capsules within which the threads may be easily seen.

Suborder **Disporea** (Doflein).—Each trophozoite produces one pansporoblast that contains two spores. The spores are wider than they are long. The trophozoites are found floating freely in the fluids of various organs of the fish and frog hosts.

Family **Ceratomyxidæ** (Doflein).—Having the characters of the suborder. Typical genus, *Ceratomyxa* Thèlohan, 1892.

Suborder **Polysporea.**[19]—Each pansporoblast produces two and usually a great number of spores. These spores are longer than they are wide.

Family **Myxidiidæ** (Thèlohan).—The spore has two polar capsules. Typically the trophozoites live as free parasites in the fluids of the internal organs of their hosts. Typical genus, *Myxidium* Bütschli, 1882.

Family **Chloromyxidæ** (Thèlohan).—The spores have four polar capsules. Typical genus, *Chloromyxum* Mingazzini, 1890.

Family **Myxobolidæ** (Thèlohan).—These forms are usually polysporous. Histozoic and usually found as cysts filled with spores. Amœboid forms are rarely found. Vacuoles that take a reddish brown stain on treatment with iodine are found in the sporoplasm. Typical genus, *Myxobolus* Bütschli, 1882.

Order **Microsporidia** (Balbiani).—More or less amœboid trophozoites. The spores pyriform, very minute, and with only one polar capsule, the latter being invisible in the living organism. Parasitic in invertebrates, particularly Crustacea and other Arthropoda. Cytozoic.

Family **Glugeidæ** (Thèlohan).—Having the characters of the order.

Group A. **Polysporogenea** (Doflein).—Many pansporoblasts are produced by the trophozoite. Each gives rise to many spores. Typical genus, *Glugea* (*Nosema*) Thèlohan, 1891.

Group B. **Oligosporogenea** (Doflein).—A single pansporoblast is produced by each trophozoite. Typical genus, ***Gurleya*** Doflein, 1898.

Order **Actinomyxidia.**—Members of this order are characterized by the possession of a double cellular envelope, three polar capsules, and eight spores that are arranged in ternary symmetry. Typical genus, *Hexactinomyxon* Stolë, 1899.

[19] Calkins comments: "The characteristics distinguishing these two suborders are not very definite and some more natural system should be worked out with further knowledge of the group. Under the polysporous forms, for example, Spherospora is exceptional in having nearly spherical spores."

Subphylum SPOROZOA—Continued.

Class Neosporidia (Schaudinn)—Continued.

Order Haplosporidia (Caull. and Mesnil).—A group of which little is known concerning either the life histories or affinities. They are grouped by Caullery and Mesnil as follows:

Family Haplosporidiidæ (Caull. and Mesnil).—Parasites of annelids; of amœboid form. They reproduce by encapsulated merozoites, which may bear spines or processes. Typical genus, *Haplosporidium* Caullery and Mesnil, 1905.

Family Bertramiidæ (Caull. and Mesnil).—Includes two genera, *Bertramia* and *Ichthyosporidium*, and with four species parasitic in fish, annelids, and rotifers. Typical genus, *Bertramia* Caullery and Mesnil, 1905.

Family Celosporidiidæ (Caull. and Mesnil).—Includes three genera: *Celosporidium* Mesnil and Marchoux, 1898; *Polycaryum* Stempell, 1901; and (?) *Blastulidium* Ch. Perez, 1903, mainly parasites of copepods. Doubtful forms, including the genera *Schewiakovella* Caull. and Mesnil, 1905, parasite of *Cyclops*, etc.; *Chytridiopsis* A. Schn., 1884, parasite of *Tenebrio molitor* and of *Blaps; Celosporidium* Crawley, of *Blattella germanica; Lymphosporidium* Calkins, 1898; and *Rhinosporidium* Minchin and Fantham, the cause of nasal tumors in man.

Order Sarcosporidia.—Parasites in muscle cells of vertebrates. The parasites occur in large sacklike spore cases (Miescher's tubules or Rainey's capsules) with double membranes. Erdmann[20] has described an amœboid phase and schizogony in the case of *Sarcocystis muris*, of the mouse. Crawley[21] counsels the removal of the Sarcosporidia to the Telosporidia on the conclusion that they are related to the Coccidiida. One genus, *Sarcocystis* Lankester, 1882.

Subphylum INFUSORIA.—The most highly developed of the Protozoa. The motile organs are in the form of flexible, vibratile, protoplasmic processes known as cilia. These differ from flagella in being shorter. The stroke, also, is different, being sharp and quick in the propulsive movement and slower and less forceful on the recovery. In some forms these cilia may be united to form cirri, membranelles, and membranes. The cilia may be permanent or they may be limited to young stages of the organism. Most forms show the presence of dimorphic nuclei, the macronucleus (meganucleus) and the micronucleus. Reproduction is by simple division, transverse to the long axis of the cell, or by budding. The nutrition is of the holozoic type—occasionally saprozoic.

Class Ciliata.—Cilia are present at all stages of the life cycle. Mouth and anal pore usually present. A complex canal system is often found in connection with the contractile vacuole. Reproduction by transverse division.

[20] Erdmann, Rhoda, Schizogony in the life cycle of Sarcocystis muris, *Proc. Soc. Exp. Biol. & Med.* (1915), 11, 152.

[21] *Nature* (1917), 100, 250.

Subphylum **INFUSORIA**—Continued.

Class **Ciliata**—Continued.

Order **Holotrichida.**—Similar cilia uniformly distributed over the body. These may lengthen about the mouth. Trichocysts may be distributed over the body or restricted to special areas.

Suborder **Gymnostomina.**—The mouth opens only during food-taking. There is no undulating membrane about the mouth.

Family **Enchelinidæ.**—Mouth round or oval in outline and either terminal or subterminal. Food-taking is usually a literal act of deglutition. Typical genera: *Enchelys* Hill, 1752, Ehrenberg, 1838; *Actinobolus* Stein, 1867.

Family **Trachelinidæ.**—Body asymmetrical or distinctly bilateral. The dorsal aspect is slightly arched. Mouth terminal or subterminal and in some cases drawn out to form a long proboscis. When an œsophagus or gullet is present, it usually is supported by a framework of rods or a tubelike structure. Œsophagus may be absent. Typical genus, *Dileptus* Dujardin, 1841.

Family **Chlamydodontidæ.**—Mouth usually in the posterior region. General body form kidney-shaped or oval. Mouth almost always open. Pharynx supported by a framework of rods or by a smooth, firm tube.

Subfamily **Nassulinæ.**—The body is completely ciliated. Typical genus, *Nassula* Ehrenberg, 1833.

Subfamily **Chilodontinæ.**—Body generally flattened. The cilia on the dorsal aspect are stronger, and they may be confined to that region. Typical genus, *Chilodon* Ehrenberg, 1833.

Subfamily **Erviliinæ.**—The invariable characteristic is the presence of a movable style, which arises from the posterior ventral surface. The cilia are restricted to the ventral surface or to a portion of it. Typical genus, *Dysteria* Huxley, 1857.

Suborder **Trichostomina.**—The mouth or pharynx is bordered at its edge by an undulating membrane or membranes. The mouth is always open. Ciliation is general.

Family **Chiliferidæ.**—Peristome area absent or at best only partially developed. Mouth in anterior half of the body or near the middle. When present the pharynx is short. Typical genus, *Colpoda* Müller, 1773.

Family **Urocentridæ.**—The cilia appear as two broad zones around the body at each end. Mouth is in the center of the ventral side and is fitted with a long tubular pharynx. Typical genus, *Urocentrum* Nitsch, 1827.

Family **Microthoracidæ.**—Small forms, asymmetrical, the mouth in the posterior region. Cilia generally dispersed, but occasionally limited to the oral region. One or two undulating membranes may be present. Typical genus, *Microthorax* Engelmann, 1862.

Family **Paramecidæ.**—There is a large triangular peristome, extending from the left anterior edge of the body to the mouth, which is sometimes in the anterior and sometimes in the

Subphylum **INFUSORIA**—Continued.
Class **Ciliata**—Continued.
Order **Holotrichida**—Continued.
Suborder **Trichostomina**—Continued.
Family **Paramecidæ**—Continued.

posterior half of the body. Typical genus, *Paramecium* Stein, 1860.

Family **Pleuronemidæ**.—A long peristome runs along the ventral side terminating at the mouth. The body is compressed laterally or dorso-ventrally. An undulating membrane borders the entire left edge of the peristome and sometimes extends around its posterior extremity to form a pocket leading to the mouth. A less highly developed membrane borders the other lip of the peristome. A well-developed pharynx may or may not be present. Typical genus, *Pleuronema* Dujardin, 1841.

Family **Isotrichidæ**.—A group of interesting parasites found in the stomachs of ruminants. The group recently reviewed by Sharp [22] in an excellent paper. Some of the members of this group are of exceedingly complex structure. The bodies are plastic, the cuticle thick and provided with evenly distributed cilia. Mouth and distinct pharynx. The family includes the genera *Isotricha, Dasytricha, Bütschlia, Cycloposthium,* and several others. Stein [23] designated the Family Ophryoscolecidæ to include organisms of the same general type. The student is referred to Sharp's paper for further information. Typical genus, *Isotricha* Stein, 1859.

Family **Opalinidæ**.—The oval bodies may be short or even stumpy or they may be long and wormlike. Mouth and pharynx absent. Typical genus, *Opalina* Purkinje and Valentin, 1835.

Order **Heterotrichida**.—In organisms included in this order the ciliation is uniform. There is an adoral zone consisting of short cilia, which are fused to form membranelles.

Suborder **Polytrichina**.—The coating of cilia is uniform.

Family **Plagiotomidæ**.—Narrow, furrowlike peristome generally beginning close to the anterior end and running back, ventrally, to the mouth, which usually lies between the middle and the posterior end of the body. The adoral zone is usually straight and is placed along the left side of the peristome. Typical genus, *Nyctotherus* Leidy, 1849.

Family **Bursaridæ**.—Body usually short and pouchlike, but it may be elongate. The peristome is in the form of a broad and deep triangular area, the apex of which is at the mouth. The adoral zone lies on the left edge of the peristome and may extend over to the right anterior edge. Typical genera: *Bursaria* O. F. Müller, 1773; *Balantidium* Stein, 1867.

[22] Sharp, Robert G., Diplodinium ecaudatum with an account of its neuromotor apparatus, *Univ. Calif. Pub. Zoöl.* (1914), **13**, No. 4, 43.

[23] Stein, F., Ueber mehrere neue im Pansen del Wiederkäuer lebende Infusionsthiere, *Abh. d. Kais. Böhm. Ges. Wiss.* (1858), **10**, 69; cited by Sharp.

Subphylum **INFUSORIA**—Continued.
Class **Ciliata**—Continued.
Order **Heterotrichida**—Continued.
Suborder **Polytrichina**—Continued.

Family **Stentoridæ**.—The relatively short peristome is limited to the anterior end of the body, its plane lying at approximately right angles to the long axis of the body. There is an adoral zone of cilia, which may completely encircle the edge of the peristome or may end at the right-hand edge. The surface of the peristome is ciliated and shows spiral striations. The body is often highly contractile. There are no undulating membranes. Typical genus, *Stentor* Oken, 1815.

Suborder **Oligotrichina**.—The ciliation is reduced and limited to certain localized areas.

Family **Lieberkühnidæ**.—Includes forms that were first thought to be young stentors. Little is known of them.

Family **Halteriidæ**.—The ciliation is scant and scattered over the ventral and dorsal surfaces. The peristome is not provided with cilia. Typical genus, *Halteria* Dujardin, 1841.

Family **Tintinnidæ**.—The body is contained in a cup or theca, to which it is attached by a stalk. There is a ring of paroral cilia inside of the adoral zone of membranelles. Typical genus, *Tintinnopsis* Stein, 1867.

Family **Ophryoscolecidæ**.—Distinct spinelike processes appear at the posterior end, and there is a well-defined anal tube that leads to the anal pore. The peristome is deep and funnel-like. The cuticle is thick. See Family Isotrichidæ. Typical genus, *Ophryoscolex* Stein, 1859.

Order **Hypotrichida**.—In this order the cilia are limited to the ventral surface of a body that shows marked dorsoventral flattening. The cilia are frequently fused to form brushlike cirri, which are used as creeping organs and which may have a tactile function. There is an adoral zone of membranelles. Bristles are frequently present on the dorsal surface. The pharynx may be slightly developed or altogether absent.

Family **Peritromidæ**.—There are no cirri, the cilia on the ventral surface being uniform in size and arrangement. The peristome is but slightly differentiated from the rest of the frontal area. Typical genus, *Peritromus* Stein, 1862.

Family **Oxytrichidæ**.—The structure of some members of this family is often quite complex. Some species, however, are more primitive, somewhat resembling those in the family Peritromidæ, the ciliation on the ventral surface being uniform. Even here, some of the anterior and some of the posterior cilia are fused to form cirri that are spoken of as *frontal* and *anal* cirri, respectively. In the greater number of species all of the cilia are thus modified. There are strong marginal cirri that occur in perfect rows, while the ventral cirri are less regularly arranged. There is an undulating membrane on the right side of the peristome, which is in addition to the adoral zone of membranelles, and in some cases, a row of cilia between this membrane and the adoral zone. These are the paroral cilia, which form the paroral zone.

Subphylum **INFUSORIA**—Continued.
Class **Ciliata**—Continued.
Order **Hypotrichida**—Continued.
Family **Oxytrichidæ**—Continued.
Typical genera: *Oxytricha* Ehrenberg, 1830; *Stylonychia* Stein, 1859.

Family **Euplotidæ**.—Cilia and frontal, marginal, and ventral cirri greatly reduced. Anal cirri always present. The macronucleus is band-shaped. Typical genus, *Euplotes* Stein, 1859.

Order **Peritrichida**.—The body is cylindrical or cup-shaped. The cilia are reduced, generally, to those entering into the formation of the adoral zone. Secondary rings of cilia may be present. Includes some beautiful colonial forms.

Family **Spirochonidæ**.—The peristome is drawn out to a peculiar funnellike process, which may be either simple or rolled. Reproduction is by a process of budding. Parasitic forms. Typical genus, *Spirochona* Stein, 1851.

Family **Lichnophoridæ**.—There is a secondary circlet of cilia around the opposite end in addition to the adoral zone. The adoral zone is a left-wound spiral. The family contains a single genus, *Lichnophora* Claparéde, 1867. It is parasitic on marine arthropods.

Family **Vorticellidæ**.—Peritrichous ciliates, attached or unattached. Viewed from above the adoral zone forms a right-wound spiral. The under end may show a secondary circlet of cilia, which may be either temporarily or permanently present.

Subfamily **Urceolarinæ**.—The secondary circlet of cilia is permanent. It incloses an adhesive disk. There is no peristome fold. Typical genus, *Trichodina* Stein, 1854.

Subfamily **Vorticellidinæ**.—No permanent secondary circlet of cilia. A sphincterlike, contractile, peristome fold incloses the peristome. Typical genera: *Vorticella* Ehrenberg, 1838; *Zoöthamnium* Stein, 1854.

Class **Suctoria** (Acinetaria).—There are no cilia during the adult stages, but they are present during the young or "embryonic" stage. The cilia may be retained in a few cases. Tentacles, variously modified, are present. Some of these are suctorial, some adapted for piercing.

Family **Hypocomidæ**.—Permanently ciliated ventral surface and one suctorial tentacle. They are unattached. Division transverse. But one genus, *Hypocoma* Gruber, 1884.

Family **Urnulidæ**.—Small attached forms giving rise to holotrichous swarm spores. May or may not be provided with a cup or theca. There are one, two, or rarely more simple tentacles. Typical genus, *Urnula* Claparéde and Lachmann, 1858.

Family **Metacinetidæ**.—The animal lives in a theca or cup. The base of this cup is drawn out to form a long stalk. The walls are perforated for the exit of the tentacles. But one genus, *Metacineta* Bütschli, 1888.

Family **Podophryidæ**.—The general shape is globular. There may or may not be a stalk. There are numerous tentacles distributed about the entire surface, or they may be limited to the apical region.

Subphylum **INFUSORIA**—Continued.

Class **Suctoria**—Continued.

Family **Podophryidæ**—Continued.

The tentacles are prehensile and may be knobbed or pointed. Typical genus, *Ephelota* Str. Wright, 1858.

Family **Acinetidæ**.—Reproduction is typically by endogenous budding. This may be simple or multiple. Swarm spores are formed, which may be peritrichous, holotrichous, or hypotrichous. The individuals are naked and stalked or thecate and either stalked or unstalked. There are numerous tentacles, usually similar and knobbed. Typical genus, *Acineta* Ehrenberg, 1833.

Family **Dendrosomidæ**.—Suctoria that may be either simple or branched. There are no stalks or theca. The numerous tentacles are similar and grouped in tufts and are knobbed. Peritrichous swarm spores are produced. Reproduction is by endogenous budding. Typical genus, *Dendrosoma* Ehrenberg, 1838.

Family **Dendrocometidæ**.—Sessile forms, which rest upon the entire basal surface or upon a raised portion which forms a stalk. The tentacles are short and knobbed and numerous and may be distributed over the entire apical surface or be localized upon branched arms. Reproduction by endogenous spore formation, the swarmers being peritrichous. Typical genus, *Dendrocometes* Stein, 1867.

Family **Ophryodendridæ**.—There are numerous long, sometimes knobbed tentacles, supported upon proboscislike processes of the apical side. Reproduction by endogenous budding with the formation of peritrichous swarm spores. Stalked or sessile. Typical genus, *Ophryodendron* Claparéde and Lachmann, 1858.

SOME STANDARD WORKS ON THE PROTOZOA

The following does not, by any manner of means, exhaust the list of standard works on the Protozoa. Practically all of them include an exhaustive and up-to-date bibliography, and they are books that are more or less accessible to the average reader.

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TWO NEW SPECIES OF SCIARA FROM THE PHILIPPINES

By F. W. Pettey
(Cornell University, Ithaca, New York)

ONE PLATE

Through the courtesy of Dr. E. P. Felt, specimens of *Sciara*, collected in the Philippine Islands under the direction of Professor Charles S. Banks, of the department of entomology, College of Agriculture, at Los Baños, by Mr. L. B. Uichanco, have been sent to the Department of Entomology, Cornell University, for identification. The species are apparently undescribed.

Sciara bispinosa sp. nov. Plate I, figs. 2 and 4.

Male.—Length, 1 millimeter. Head black, shiny; antennæ fuscous, over two-thirds the length of the body. Thorax black, shiny, pleura fuscous. Abdomen black; hypopygium fuscous, with no small setiferous median ventral lobe at base; clasper (Plate I, fig. 2) with two stout subapical spines and a group of shorter more slender apical spines. Legs dull brown, tarsi darker; length of hind tibia and tarsus about equal. Wings (Plate I, fig. 4) hyaline; veins of medium strength; media and cubitus without setæ; base of Rs noticeably distad of the mid point between the tip of R_1 and the humeral cross vein; R_1 ends noticeably proximad of the forking of media; petiole of cubitus slightly longer than the base of media; costa extends over two-thirds of the distance between the tips of Rs and M_1; Rs ends distad of 0.85 of the wing length and noticeably proximad of the tip of M_2. Halteres fuscous.

Luzon, Laguna Province, Los Baños, March 16, 1917, College of Agriculture accession No. 18153 (*L. B. Uichanco*). Described from one male. Type in the Cornell University collection.

Sciara uichancoi sp. nov. Plate I, figs. 1 and 3.

Male.—Length, 2.3 millimeters. Head black, shiny; antennæ and palpi fuscous, anterior end of scape luteous, antennæ about as long as head and thorax. Thorax black, shiny; angle of humerus luteous; pleura dark fuscous. Abdomen black, venter fuscous, hairs whitish; hypopygium fuscous with no small median setiferous lobe, clasper with about six stout spines, two of which are stouter than the rest (Plate I, fig. 1). Coxæ and femora

luteous; trochanters black; tibiæ brownish; tarsi fuscous; hind tibia a little longer than tarsus. Wings (Plate I, fig. 3) smoky brown; R_1 and Rs strongly marked, petiole and base of fork of media extremely faint, petiole of cubitus a little over one-half as long as what appears to be the base of media; R_1 ends about opposite the forking of M; the base of Rs about midway between the humeral cross vein and the tip of R_1; costa extends over half the distance between the tip of Rs and M_1; Rs ends considerably distad of 0.85 of the wing length and considerably distad of the termination of M_2. Knobs of halteres black, pedicels luteous.

Female.—Length, 2.8 millimeters. Colored like the male. The faint media is a little more distinct than in the male specimens.

LUZON, Laguna, Mount Maquiling, August 28, 1917, College of Agriculture accession No. 18176 (*L. B. Uichanco*). Described from two males and one female. Type and allotype in the Cornell University collection. Autotype in the College of Agriculture collection, Los Baños, P. I.

ILLUSTRATION

Plate I

Fig. 1. *Sciara uichancoi* sp. nov., male clasper, × 300.
2. *Sciara bispinosa* sp. nov., male clasper, × 300.
3. *Sciara uichancoi* sp. nov., wing of male (photomicrograph).
4. *Sciara bispinosa* sp. nov., wing of male (photomicrograph).

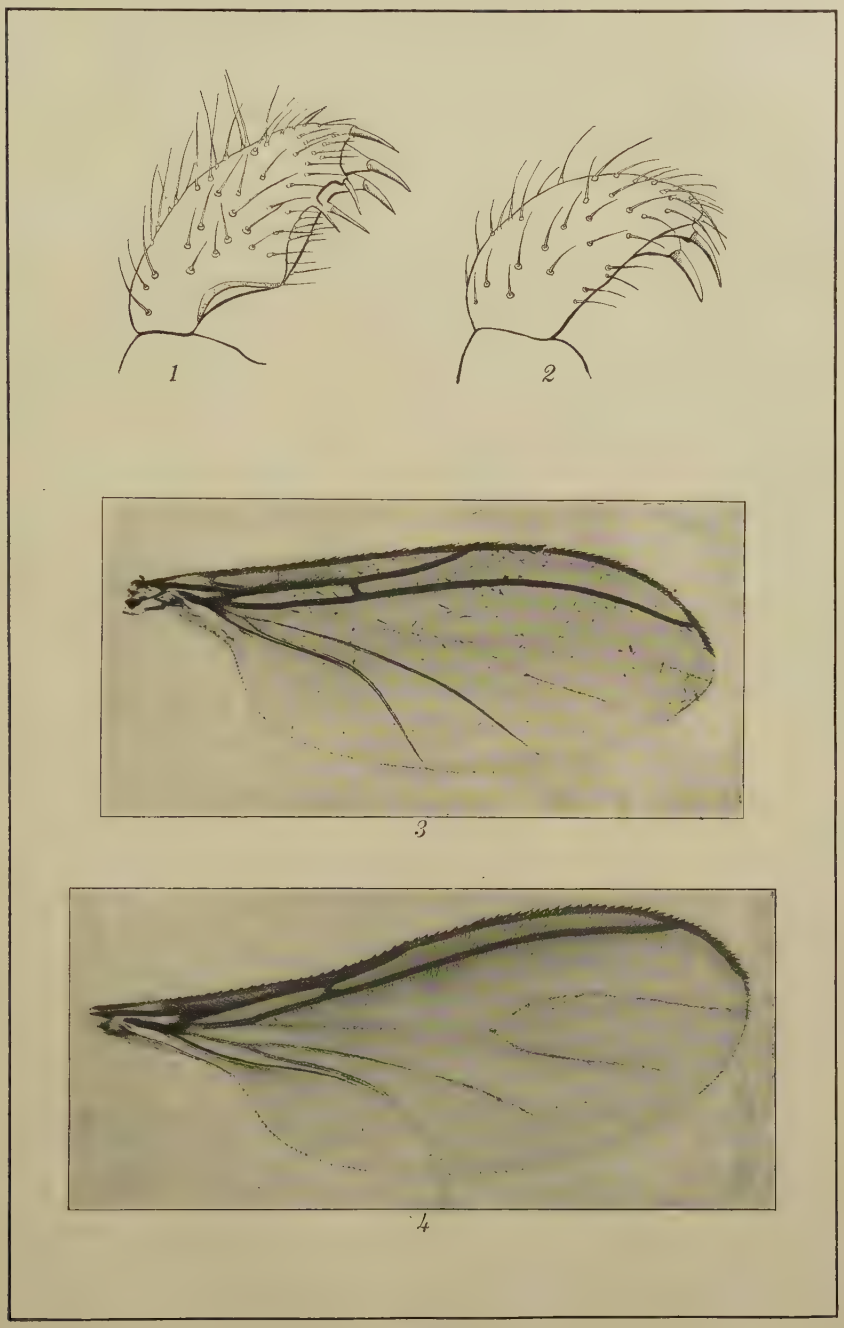

PLATE I.

Figs. 1 and 3. Sciara uichancoi sp. nov. 2 and 4. Sciara bispinosa sp. nov.

NOTES ON NEMATODE PARASITES OF PHILIPPINE BIRDS

TETRAMERES FISSISPINA (DIESING, 1860) IN PHILIPPINE CHICKENS

By LAWRENCE D. WHARTON

(*Assistant Professor of Zoölogy, University of the Philippines*)

In October, 1917, Professor Charles S. Banks brought me a number of nematode worms, which had been collected from the proventriculus of a chicken at the College of Agriculture in Los Baños. On examination these worms were found to belong to the genus *Tetrameres* Creplin, 1846. This genus contains thirteen species of worms, all of which have been found in the digestive tract of birds. However, only one species, *Tetrameres fissispina* (Diesing, 1860), has been reported as a parasite of chickens. This form was reported from this host in Brazil in 1914 by Travassos [1] and in Guam in 1915 by Ransom.[2]

Further study of the specimens furnished by Professor Banks and of others, which I have obtained here in Manila, has led to the conclusion that the Philippine species is identical with that reported by Travassos and by Ransom.

Tetrameres fissispina (Diesing, 1860).

Tropidocerca fissispina Diesing, 1860.
Acanthophorus tenuis v. Linstow, 1876.
Acanthophorus horridus v. Linstow, 1876.
Tropidocerca inflata Zuern, 1882, nec Diesing, 1860.
Tropisorus fissispinus Neuman, 1888.
Tropisurus fissispinus Railliet, 1895.

All the species of this genus are remarkable for their great sexual dimorphism, the males being long, slender white worms and the females subglobular and red or brown.

Female.—Length, 3 to 6 millimeters; diameter, 2 to 3.5 millimeters. Body subglobular, blood red, with slender conical cephalic and caudal projections. The body is transversely striated and bears four longitudinal depressions, which correspond to the median and lateral lines. The two extremities are

[1] Travassos, Paul, Sobre as especies brazilieras do genero Tetrameres Creplin, 1846, *Memorias do Instituto Oswaldo Cruz* (1914), 6, 150–162.

[2] Ransom, B. H., Proceedings of the Helminthological Society of Washington, *Journ. Parasit.* (1915), 2, 93.

more or less retractile and movable from side to side, the anterior or cephalic projection measuring 1.2 millimeters in length and the posterior 0.5 to 0.9 millimeter.

The mouth is at the end of the cephalic projection and is surrounded by three lips, each of which bears a terminal papilla. It opens into a rounded buccal cavity about 20 μ in diameter. The œsophagus extends throughout the length of the projection and opens into a large sacklike intestine, which continues through the body and into the caudal projection, where it opens about 0.2 millimeter from the posterior end. The intestine generally contains a mass of black coloring matter, so that it can be easily followed through the body. At the junction of the œsophagus with the intestine is a mass of unicellular glands.

The genital organs occupy the greater part of the body and consist of a mass of much coiled and twisted tubes. The uteri are double and unite to form a long vagina, which opens ventrally at the junction of the caudal extremity with the body. Just anterior to the opening there is a round sacklike diverticulum of the vagina. The uterus and the vagina with its diverticulum are always filled with eggs in different stages of segmentation. The eggs are oval and thin-shelled and measure 48 to 56 μ in length by 26 to 30 μ in breadth. They contain a coiled embryo when they are ready to leave the body of the parent worm.

Male.—Length, 4 to 5 millimeters; diameter, 0.11 to 0.2 millimeter. The body is threadlike and white and is transversely striated. Along each lateral and median line is a single row of small spines, which point backward. These spines begin just back of the buccal cavity and extend beyond the level of the anus. In the anterior and posterior regions they are about 20 μ apart, but in the middle of the body they are separated by as much as 115 μ.

In the male the alimentary canal is distinctly different from that of the female. It is divided into a short buccal capsule, an œsophagus composed of a short, slender, muscular portion and a long, wide, posterior portion that opens into a tubelike intestine; the latter does not show any of the black color that is so prominent in the female intestine. The anus opens about 0.25 millimeter from the tip of the tail.

There are two unequal spicules, a short sharp-pointed one 115 μ long and 4 μ in thickness and a long one measuring 320 μ in length by 15 μ in thickness and with a rounded end.

Habitat.—The female worms lie embedded in the gastric glands of the proventriculus. They can be seen from the outside as small, round red spots in the walls. The males lie either free

in the lumen of the proventriculus or with one end buried in the duct of a gland. On account of their small size they are difficult to find and also seem to be much less numerous than the females. It is probable that they die after fertilization is accomplished, as I have never found any males in chickens in which the females appeared to be old.

Host.—Tetrameres fissispina has been reported from the mud hen (*Fulica atra*), the duck (*Anas boscas*), and the chicken (*Gallus domesticus*). Since receiving the specimens from Professor Banks, I have examined 100 chickens here in Manila and have found this parasite in 76 of them. It is by far the commonest parasite that I found. I have not had the opportunity to make examinations of ducks to see if it is also found in them.

Pathogenicity.—None of the chickens examined by me have shown any gross pathological conditions that could be traced to the presence of the worms in the walls of the alimentary canal. However, I believe that the presence of these worms, particularly in young chickens, must undoubtedly interfere with the secretion of the glands and result in a general lowering of the vitality of the infested individuals.

A FEW RARE BIRDS FROM LUZON AND MINDORO

By JOHN T. ZIMMER
(*Port Moresby, Papua*)

In the collection of birds secured by me in the Philippines during 1913 to 1916, inclusive, are various specimens that through the rarity of the species concerned, unusual distribution, or peculiar plumage represent captures of special interest. One form of thickhead (Laniidæ) is described as new. Numbers in tables and in parentheses after discussions of species refer to my collection, which is at Lincoln, Nebraska, U. S. A.

Acknowledgments are made to Mr. R. C. McGregor, of the Philippine Bureau of Science at Manila, for the freedom of the collection at that institution and for other generous assistance.

Turnix whiteheadi Grant.

On the night of October 25, 1914, I was crossing a stretch of cogon-covered hills near Bondog Point in the southern part of Tayabas Province, Luzon. I had a small acetylene lamp fastened to my hat and was on the lookout for whatever might appear in the ray of light before me, when suddenly a covey of button quails got up from underfoot and, as usual, scattered in all directions. One of the birds, blinded by the glare of the light, flew directly into my hands, and I captured it before it could escape. Upon examination it proved to be a female *Turnix whiteheadi*. The habits and habitat of this species appear to be little known, since the only specimens heretofore on record were trapped by Filipinos and were sold in the Manila markets. (No. 1117.)

Leucotreron marchei (Oustalet).

It has been supposed that this handsome pigeon was confined to the Lepanto and Bontoc mountains of northern Luzon, but it proves to occur in the southern part of Luzon also. On December 31, 1915, I secured an adult female from a small flock, at about 1,500 meters' elevation (5,000 feet) on Mount Banahao, Laguna Province. This specimen is identical with one from the north. (No. 1333.)

Sterna sinensis Gmelin.

This tern is by no means common on Luzon. My only specimen is a female, which I shot out of a small flock wheeling over the Las Piñas salt beds, near Manila, on September 12, 1915. (No. 1278.)

Ægialitis alexandrina (Linnæus).

At Bondog Point, Tayabas Province, on October 20, 1914, I collected a female Kentish plover, which is, so far as I know, the first one taken on Luzon. (No. 1115.)

Totanus eurhinus (Oberholser).

I have a female redshank, which I took on the Las Piñas salt beds, near Manila, on August 30, 1914. It was quite alone when taken. This is the first Luzon record for this bird. (No. 1052.)

Ardea cinerea Linnæus.

On October 19, 1914, I secured a female of this interesting heron at Bondog Point, Tayabas Province. The only other published records for Luzon are those by McGregor.[1] The species is rare throughout the Archipelago. (No. 1112.)

Ceyx melanura Kaup.

I found this little gem of the kingfisher family to be rather rare. My only specimen is a male, taken on October 4, 1914, at a few hundred feet elevation on Mount Maquiling, Laguna Province, Luzon. (No. 1086.)

Hemiprocne major (Hartert).

In the Additions and Corrections to his Manual of Philippine Birds, McGregor places the whiskered swifts from Mindanao, Samar, Sibutu, and Sulu in the species *comata* (Temminck). While not questioning the occurrence of *comata* on Mindanao, I am of the opinion that not all of the Mindanao birds belong to that form. This conclusion is reached on the basis of a pair of these swifts that I obtained on Mount Larugan, Bukidnon Province, which are larger than some of my Luzon specimens. The following comparison of wing measurements will illustrate:

TABLE I.—*Measurements of Hemiprocne from Mindanao and from Luzon.*

No.	Sex.	Locality.	Date.	Wing.
				mm.
1242	♀	Bukidnon Province, Mindanao	May 19, 1915	137
1241	♂	do	do	135
1268	♀	Antipolo, Rizal Province, Luzon	Aug. 15, 1915	132
1310	♀	Mount Banahao, Laguna Province, Luzon	Nov. 22, 1915	136
1298	♀	Mount Maquiling, Laguna Province, Luzon	Oct. 10, 1915	138
1297	♂	do	do	133

[1] Manual of Philippine Birds. Bureau of Science, Manila (1909), 163, and *This Journal, Sec. D* (1916), 11, 273.

Hierococcyx fugax (Horsfield).

I have four specimens of this interesting cuckoo taken on Luzon. All but one are immature birds. Their habitat seemed to embrace both the lower mountain slopes and the bamboo thickets of the lowland.

TABLE II.—*Specimens of Hierococcyx fugax.*

No.	Sex.	Locality.	Date.
1169	♂ ad.	Mount Mariveles, Bataan Province, Luzon	January 1, 1915.
1206	♂ imm.	do	April 2, 1915.
859	♀ imm.	Manila, Luzon	January 18, 1914.
1087	♀ imm.	Mount Maquiling, Laguna Province, Luzon	October 9, 1915.

Cuculus canorus Linnæus.

Philippine records for any of the species of the present genus are not numerous, and Luzon records are quite lacking. A fine male, which I collected on Mount Mariveles, Bataan Province, on April 3, 1915, thus represents the first Luzon record of the present species. My bird was taken along Lamao River at only a few hundred feet elevation. (No 1207.)

Centropus unirufus (Cabanis and Heine).

On November 7, 1913, while among the mountains of Rizal Province, Luzon, I shot a fine male rufous cuckoo, the first and last one I ever encountered. (No. 783.)

Pitta atricapilla Lesson.

The black-headed pitta is not rare in the Philippines, and I have specimens from several of the Islands. One female, which I collected at Bondog Point, Tayabas Province, Luzon, varies from the ordinary in the possession of more or less distinct, though irregular streaking; this is in the form of obovate or triangular marks along the shafts of certain feathers. On the back and scapulars it is black, conspicuous against the shining green of those parts, but on the breast and flanks it is a faint drab, visible only in certain lights. A male from Balabac has a trace of the dorsal streaking, but only two feathers are thus marked. The Luzon bird is dated October 25, 1914. (No. 1118.)

Hirundo gutturalis Scopoli.

A male and a female *Hirundo,* taken at Las Piñas, Rizal Province, Luzon, on September 19, 1915, are so near to *H. rustica* Linnæus that it is a question whether or not they should be

referred to that species rather than to the present one. The black pectoral band is quite complete; and the under parts are decidedly rufous, much more so than in several other specimens taken from the same flock as these, and still others from different localities. However, since there are no definite records of *H. rustica* from Luzon and since the two forms apparently intergrade, I will leave this note as it stands. (No. 1289, male; No. 1287, female.)

Hirundo striolata (Boie).

I found a large colony of mosque swallows nesting under an old bridge at Tiaong, Tayabas Province, Luzon, where I secured four specimens on August 11, 1915.

Cyornis herioti Ramsay.

This rare flycatcher was described from northern Luzon, where it was supposed to be restricted. I was accordingly agreeably surprised on March 29, 1914, to find one of them on Mount Maquiling, Laguna Province, at about 305 meters' elevation (1,000 feet). It was alone when taken. (No. 955.)

Rhipidura hutchinsoni Mearns.

I have a single female of this fantail, which I took in Bukidnon Province, Mindanao, near Sumilao. This species is confined to Mindanao and has been taken previously only on Mount Malindang at from 1,200 to 2,700 meters (4,000 to 9,000 feet). My specimen was taken at not more than 900 meters (3,000 feet). The Bukidnon natives called this bird *ka-tú-pai*, although they applied the same name to *Xeocephus cinnamomeus*. Mearns says, "chest * * * deep cinnamon," but this part in my specimen is nearer Ridgway's apricot buff.

Culicicapa helianthea (Wallace).

This little flycatcher is not rare in certain localities, but is not distributed throughout its range. I found it only on Mount Banahao, Laguna Province, Luzon, and at Sumilao, Bukidnon Province, Mindanao.

TABLE III.—*Specimens of Culicicapa helianthea.*

No.	Sex.	Locality.	Date.
1322	♂	Mount Banahao, Laguna Province, Luzon	December 30, 1915.
1323	♂	do	Do.
1306	♂	do	November 21, 1915.
1559	♀	do	December 7, 1916.
1252	♂	Sumilao, Bukidnon Province, Mindanao	May 23, 1915.
1251	♀	do	Do.

Cryptolopha olivacea (Moseley).

I have a number of specimens of this species from Laguna Province, Luzon. Most of them were taken from mixed flocks of *Acanthopneuste, Pardaliparus,* and *Zosterornis,* rarely alone.

TABLE IV.—*Specimens of Cryptolopha olivacea.*

No.	Sex.	Locality.	Date.
1299	♂	Mount Maquiling, Laguna Province, Luzon	October 31, 1915.
1198	♂	do	March 21, 1915.
1275	♂	do	September 5, 1915.
1016	♂	do	June 7, 1914.
1204	♀	do	March 28, 1915.
1213	♀	do	April 11, 1915.
1324	♂	Mount Banahao, Laguna Province, Luzon	December 30, 1915.

Cryptolopha nigrorum Moseley.

My only specimen of this bird was taken at Baguio, Mountain Province, Luzon, on May 10, 1914. It is a male. (No. 996.)

Cryptolopha mindanensis Hartert.

I have a male of this little warbler, taken at Sumilao, Bukidnon Province, Mindanao, on May 14, 1915. (No. 1225.)

Eumyias nigrimentalis (Grant).

I hunted long for this flycatcher in south-central Luzon, but did not find it until I began collecting on Mount Banahao. There I succeeded in getting three specimens, all males, on as many different occasions. (No. 1305, November 21, 1915; No. 1323, December 30, 1915; No. 1557, December 7, 1916.)

Edolisoma cærulescens (Blyth).

There appear to be numerous records for this bird from Luzon, but I only saw it on October 12, 1914, when I secured a female at Bondog Point, Tayabas Province. (No. 1095.)

Iole everetti (Tweeddale).

One specimen, a female, is in my collection, taken at Mailag, Bukidnon Province, Mindanao, on May 19, 1915. It was in the forest at the foot of a range of hills. (No. 1247.)

Zosterornis whiteheadi Grant.

Whitehead's tree babbler is common at Baguio, Benguet Subprovince, Luzon, and strangely enough occurs on Mount Banahao, Laguna Province. The Mount Banahao specimens are somewhat distinguishable from the average northern bird by

their brighter coloration above and below, but the difference is hardly worthy of recognition by name.

An interesting question is raised by the occurrence on Mount Banahao of several avian species that are found there but not on other mountains near to it. The present species furnishes one example, *Leucotreron marchei* another. These birds were taken at low elevations on Mount Banahao, from 600 to 900 meters (2,000 to 3,000 feet), heights which are found on Mount Maquiling, for instance, where these birds do not occur. The explanation may be that some of the higher mountain forms, such as the present, are accustomed to descend to lower levels but do not inhabit isolated peaks like Mount Maquiling, where the greater altitudes are not available for retirement when desirable. Undoubtedly a vertical migration of sorts takes place on the mountains in the Philippines, which brings numbers of birds to lower altitudes during the rainy seasons and sends them upward when the lower slopes of the hills feel the effect of the dry weather. To lend strength to this theory, it may be stated that the rains were prevalent about Mount Banahao when these observations were made in December.

I have seen also on Mount Banahao, at over 1,800 meters' elevation (6,000 feet), a black thrush, *Planesticus* sp.?, and a *Phyllergates* near *philippinus*, neither of which was secured. Owing to the height at which they were seen, they hardly enter the above discussion. My specimens of *Z. whiteheadi* are as follows:

TABLE V.—*Specimens of Zosterornis whiteheadi.*

No.	Sex.	Locality.	Date.
994	♂	Baguio, Benguet Subprovince, Luzon	May 10, 1914.
1000	♂	do	May 11, 1914.
1001	♀	do	Do.
1321	♂	Mount Banahao, Laguna Province, Luzon	December 30, 1915.
1325	♂	do	Do.
1332	♂	do	December 31, 1915.
1330	♀	do	Do.

Zosterornis affinis McGregor.

This interesting species has been known heretofore from a single male collected in 1904 on Mount Mariveles, Bataan Province, Luzon, by A. Celestino. I have since collected a number of specimens on Mount Maquiling, Laguna Province, including the first known female of the species.

The female may be described as indistinguishable from the

male type of the species, with which I have carefully compared it.

The birds were usually associated with *Pardaliparus elegans* and *Acanthopneuste borealis*, although my first specimen was a solitary individual. The habitat was the area of lower mountain slopes of the forest up to 610 meters (2,000 feet).

TABLE VI.—*Specimens of Zosterornis affinis.*

No.	Sex.	Locality.	Date.
956	♂	Mount Maquiling, Laguna Province, Luzon	March 29, 1914.
1023	♂	do	June 14, 1914.
1201	♂	do	March 28, 1915.
[a] 1195	♀	do	March 21, 1915.
1212	♀	do	April 11, 1915.

[a] Type of the female.

Brachypteryx poliogyna Grant.

I have a male of Grant's shortwing, which I took at 2,012 meters' elevation (6,600 feet) on Mount Banahao, Laguna Province, on January 1, 1916. (No. 1334.)

Pratincola caprata (Linnæus).

This species does not seem to have been recorded from Mindanao, but it is certainly abundant over the Bukidnon highlands. I was under the impression that the species was known from that island, or I should have taken specimens in May, 1915, when I was in the region. I had left the locality when I discovered my mistake.

Orthotomus chloronotus Grant.

Most of the tailorbirds in the region about Manila are *Orthotomus derbianus*, but on the lower slopes of some of the mountains there are a few of the present form. I have a male from Antipolo, Rizal Province, and another from Lamao, Bataan Province. The habits of the two species are alike.

TABLE VII.—*Specimens of Orthotomus chloronotus.*

No.	Sex.	Locality.	Date.
896	♂	Antipolo, Rizal Province, Luzon	February 1, 1914.
1163	♂	Lamao, Bataan Province, Luzon	December 31, 1914.

Acanthopneuste xanthodryas (Swinhoe).

I find among my series of *Acanthopneuste* several specimens that are referable to *A. xanthodryas* rather than to *A. borealis*,

by reason of the longer first primary and general tone of coloration. I believe that *A. xanthodryas* is commoner than is supposed, but this is a difficult fact to prove, since the two forms are so much alike and both keep to the upper foliage of the forest.

TABLE VIII.—*Specimens of Acanthopneuste xanthodryas.*

No.	Sex.	Locality.	Date.
849	♂	Manila, Luzon	January 4, 1914.
980	♂	Bautista, Pangasinan Province, Luzon	April 8, 1914.
1111	♂	Bondog Point, Tayabas Province, Luzon	October 19, 1914.
1081	♀	Las Piñas, Rizal Province, Luzon	September 27, 1914.
1233	♀	Mailag, Bukidnon Province, Mindanao	May 18, 1915.

Horornis seebohmi (Grant).

I have two examples of this little bush warbler from Baguio, Mountain Province, Luzon, which were collected on May 12, 1914. The first one gave me considerable trouble to collect. I could hear it singing its "o-o-o-o I-see-you-a-seet!" only a few yards away in the low bush and grasses and could likewise hear its sharp "chip" as it moved about near the ground, but it was fully fifteen minutes that I strained my eyes before I finally saw the skulking songster and secured it. The second one was obtained only a few minutes afterward. (No. 1005, female; No. 1006, male.)

Hyloterpe crissalis sp. nov.

Characters of the species.—Similar to *Hyloterpe albiventris* Grant, but throat paler and crissum decidedly yellower.

Type.—No. 1336, male, adult, collection of John T. Zimmer; Mount Banahao, 914 meters (3,000 feet), Laguna Province, Luzon, P. I., January 3, 1916.

Description.—Above dark olive green, scarcely brighter on the rump and upper tail coverts; remiges and rectrices blackish brown, broadly edged with bright olivaceous; top of head browner than the back; cheeks and ear coverts brownish olive like the crown; chin and throat grayish white, the feathers with blackish shafts and dusky streaks; breast grayish olive, feathers with median dusky streaks; abdomen and flanks buffy white, indistinctly streaked with dusky; crissum lemon yellow, much brighter than in *H. albiventris*, but not so bright as in *H. fallax* McGregor; axillars and wing lining white with a yellowish tinge. Bill black; feet dull gray; iris brown. Length (of skin), 152 millimeters; wing, 80.5; tail, 65; tarsus, 21; culmen from base, 15.5; bill from nostril, 10.

A male paratype was taken at the same locality on December 30, 1915. (No. 1326.)

Rhabdornis minor Grant.

I have a female creeper of this species, which I took at Sumilao, Bukidnon Province, Mindanao, on May 14, 1915. It differs slightly from the usual plumage of this form in that the feathers of the breast and sides of lower throat are bordered with dull grayish brown and the mantle feathers are not so conspicuously white-shafted. (No. 1224.)

Zosterops basilanica Steere.

I shot a female *Zosterops basilanica* in the Mindanao highlands on May 18, 1915. It was taken from the trees bordering a river at Mailag, Bukidnon Province. (No. 1234.)

Zosterops aureiloris Grant.

I have four males of this beautiful little silvereye taken on the slopes of Mount Maquiling and Mount Mariveles at approximately 460 meters' elevation (1,500 feet). Each bird taken was secured from a group of three or four of the species. They are very active and energetic little creatures.

TABLE IX.—*Specimens of Zosterops aureiloris.*

No.	Sex.	Locality.	Date.
960	♂	Mount Maquiling, Laguna Province, Luzon	March 29, 1914.
1025	♂	do	June 14, 1914.
1154	♂	do	December 20, 1914.
1159	♂	Mount Mariveles, Bataan Province, Luzon	December 31, 1914.

Dicæum xanthopygium Tweeddale.

This flowerpecker was not common, but I occasionally saw it in the mountains of south-central Luzon, usually in company with *D. papuense* Gmelin. I have two specimens, both males. They were collected on Mount Maquiling, Laguna Province, Luzon, on February 22 and June 1, 1914, respectively. (Nos. 913 and 925.)

Dicæum obscurum Grant.

I have collected *Dicæum obscurum* on Mount Maquiling, Luzon, at about 600 meters' elevation (2,000 feet) and have two males in my collection taken there on February 15 and June 14, 1914, respectively. (Nos. 908 and 1027.)

Dicæum nigrilore Hartert.

I secured a female of the present species at Sumilao, Bukid-

non, Mindanao, on May 14, 1915. It was among the trees bordering a deep cañon. (No. 1223.)

Prionochilus inexpectatus Hartert.

This flowerpecker was not very common in my experience. I have two females from Luzon and one male from Mindoro.

TABLE X.—*Specimens of Prionochilus inexpectatus.*

No.	Sex.	Locality.	Date.
1033	♀	Mount Maquiling, Laguna Province, Luzon	June 28, 1914.
1186	♀	----do----	March 7, 1915.
1532	♂	San Jose, Mindoro	April 17, 1916.

Eudrepanis jefferyi Grant.

A female of this species that I have differs from the specimens in the Bureau of Science collection in being decidedly lighter above and below and in possessing a more or less distinct white loral spot. It was taken on Mount Banahao, Laguna, Luzon, on January 3, 1916, at about 914 meters' elevation (3,000 feet). (No. 1235.)

Cinnyris flagrans (Oustalet).

This beautiful little sunbird appears to be well distributed over south-central Luzon, but is not common anywhere. All the individuals I have seen were in mixed flocks of related forms.

TABLE XI.—*Specimens of Cinnyris flagrans.*

No.	Sex.	Locality.	Date.
1127	♂	Mount Maquiling, Laguna Province, Luzon	November 15, 1914.
1137	♂	Longos, Laguna Province, Luzon	November 28, 1914.
1313	♂	Silang, Cavite Province, Luzon	December 5, 1915.
1329	♂	Mount Banahao, Laguna Province, Luzon	December 30, 1915.

Oriolus albiloris Grant.

On April 4, 1915, I secured a fine female of this rare, forest-inhabiting oriole at Mariveles, Bataan Province, Luzon. It was on the lower slopes of the mountain. (No. 1208.)

Sturnia philippensis (Forster).

The only Luzon specimen of this starling that I have was taken on October 11, 1914, at Bondog Point, Tayabas Province, Luzon. (No. 1091.)

REPTILES OF SULU ARCHIPELAGO

By Edward H. Taylor

(*From the Section of Ichthyology, Biological Laboratory, Bureau of Science, Manila*)

THREE PLATES AND ELEVEN TEXT FIGURES

While on a fisheries exploration in Sulu Archipelago small collections of reptiles were made on several of the islands visited. As zoölogical collecting was only of secondary consideration on the trip, the attention that such collecting merited was not given to it. However, some specimens taken are new and are of much interest and importance. The known limits of distribution of several Philippine species were extended and many rare species and three species heretofore unknown to the Philippine fauna were found. The following species are described as new:

1. *Luperosaurus joloensis.*
2. *Hemiphyllodactylus insularis.*
3. *Lepidodactylus divergens.*
4. *Sphenomorphus biparietalis.*
5. *Brachymeles suluensis.*
6. *Brachymeles vermis.*

The following species are here recorded for the first time from the Philippine Islands:

1. *Mabuya rudis* Boulenger.
2. *Riopa bowringi* Günther.
3. *Lepidodactylus woodfordi* Boulenger.

Of the forty-seven species here listed, four are known only from Mindanao and northern Philippine Islands; forty-three are found in the Sulu Archipelago and in Basilan. Of this number nineteen are common to Mindanao, Sulu, and Borneo; eight species are common to Mindanao and Sulu only; six are common to Borneo and Sulu, but are not known to occur in Mindanao; seven species are known only from Sulu; two are common to Sulu and other northern Philippine Islands, but as yet are not known from Mindanao; and one is common to Sulu and New Guinea. This tells but little regarding actual faunal relationships, as Mindanao, Borneo, and Sulu Archipelago have been but little explored zoölogically. Unfortunately very few specimens were taken or observed on the Sibutu Group of islands, which is the group nearest the Borneo coast. The collection made on the Borneo coast also was a very small one, reptiles, especially snakes, being rather rare. A planter living at Tunku Point told me he had seen only a single snake in two years' residence on his plantation.

LIZARDS

Gymnodactylus annulatus Taylor. Text figs. 1 and 2.

This species was found to be especially common on nearly all the islands visited. Specimens were found under logs, rocks,

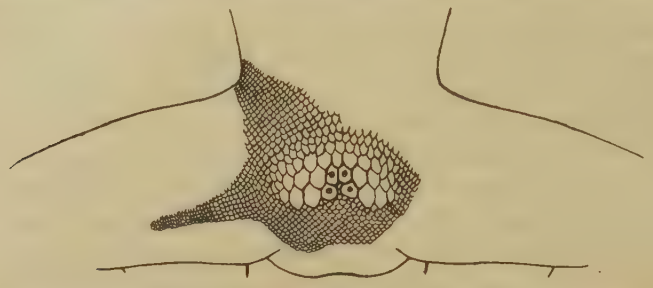

FIG. 1. *Gymnodactylus annulatus* Taylor, from Sulu, preanal pores, variation. × 3.

rotten stumps, and in other similar habitats. These differ from the type specimen in having fewer preanal pores. There are three to five pores, four being the usual number. Slight differentiation was noted among specimens from different islands in the number, shape, and arrangement of the scales bordering the preanal pores. A very large series was preserved.

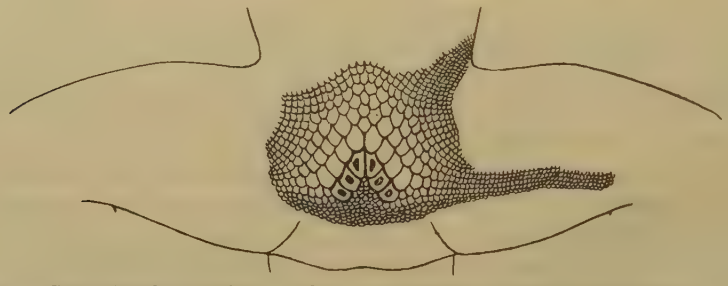

FIG. 2. *Gymnodactylus annulatus* Taylor, from Mindanao, preanal pores, typical. × 3.

Gekko gecko Linnæus.

Specimens were taken on Jolo, at Siet Lake and Camp Romandier. A single specimen was obtained from Marongas Island near Jolo. Their unmistakable call was heard on several other islands, but no others were taken. The females have the preanal scales perforated, and they resemble the preanal pore scales of the males, save that the perforations are distinctly smaller.

Gekko monarchus Duméril and Bibron.

Two specimens were obtained on Bongao at an elevation of about 500 meters. They were found hiding under the loose bark of a tree, 3 meters from the ground. Both specimens are females

and are much darker than specimens from Mindanao. The white granules on the back form rather indistinct transverse lines. The median double row of black spots is present but dim, with some spots confluent.

Cosymbotus platyurus Schneider.

Specimens were taken in Zamboanga, Basilan, Bongao, Simonor, and Sitanki. The cutaneous expansion from axilla to groin is apparently wider in these than in specimens from Negros or Manila with which they were compared.

Hemidactylus frenatus Duméril and Bibron.

Very common throughout the Archipelago; numerous specimens were taken.

Peropus mutilatus Weigmann.

A very common forest species, present on nearly all the islands visited.

Luperosaurus joloensis sp. nov. Plate I, fig. 8; text fig. 3.

Type.—No. 1872, female, Bureau of Science collection; collected at Siet Lake, Jolo, September 22, 1917, by E. H. Taylor.

Description of type.—Snout squarish, the rostral upright, longer than broad, with two slight depressions in the upper part, entering from near the median internasal; nostril surrounded by a raised prominence consisting of rostral, first labial, a postnasal, and two supranasals; last three scales coequal; eleven upper labials, the last two very small, second and third larger than first; a row of slightly enlarged scales above the upper labials, those immediately behind the postnasal largest; mental almost triangular, differentiated from the labials; a pair of hexagonal chin-shields followed by a single median scale; eleven lower labials, last three very small; eighth upper and eighth lower labials below center of eye; two or three rows of scales bordering the lower labials slightly enlarged; forehead concave, the granules on the snout larger than those on back or occiput; ear opening narrow, oblique; granules on the side and on part of head and neck intermixed with numerous spinelike scales; no lateral fold, but several enlarged scales arranged in a more or less regular row from axilla to groin; a fold of skin present about legs, more prominent on the posterior aspect of hind legs; scales on belly larger than on throat or back; a row of enlarged scales in the femoral and preanal region, sixteen on each side beginning on the knee and meeting medially at a broad angle, some of the scales apparently perforated; behind

this row, in front of anus, an angular row of much enlarged scales; anus not covered by an angular flap of skin; tail contained in distance from snout to vent one and one-half times; tail tapering gradually, rather flattened below; the annulations distinctly marked above; laterally two spinelike scales on each annulation pointing backward; scales on upper side larger than those on back, the annulations marked by a transverse row of scales slightly more prominent than others; below, scales arranged in transverse rows, the annulations marked by a row of slightly larger scales; a single prominent scale below at the base of tail on either side; adpressed limbs meet; digits half-webbed; claws

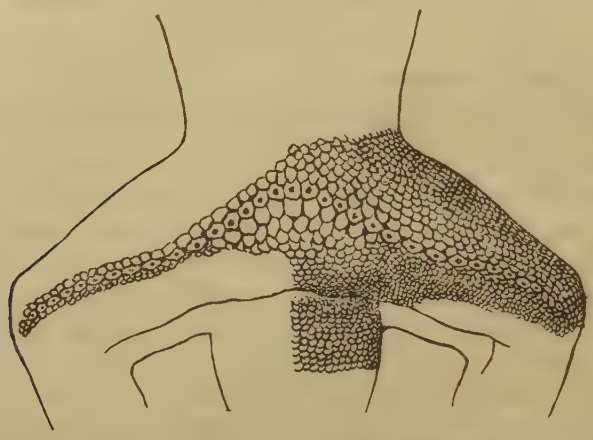

FIG. 3. *Luperosaurus joloensis* sp. nov., cotype from Jolo, preanal pores. About × 4.

present on all save inner digits; lamellæ on outer extremities of digits divided, about six on longest toe, followed by a few undivided scalelike lamellæ; diameter of eye less than its distance from nostril or auricular opening.

Color in life.—Above russet brown, with indistinct grayish markings on side of snout, occiput, sides of neck, and across the back; below yellowish, mixed with flecks of brown. Tail indistinctly barred above; grayish brown below.

Measurements of Luperosaurus joloensis sp. nov.

	mm.
Total length	59
Snout to vent	36
Tail	23
Width of head	5.5
Length of head	10
Axilla to groin	17
Foreleg	10.5
Hind leg	14.7

Variation.—A second specimen captured in the same immediate locality is a male and consequently differs from the type (an adult female containing undeveloped eggs) in the presence of distinct femoral pores. There are thirty-one of these in a continuous series from knee to knee, forming a distinct arch in the preanal region. The tail is missing. The color is brown, with a wide occipital spot of gray and black mixed and five irregular bands across the back of gray and black intermixed. The length from snout to vent is 27 millimeters.

Remarks.—This species differs much from other known species of this genus. The presence of chin-shields, spiny scales on side of neck and head, the much fewer labials, and the large number and the arrangement of the femoral pores are all distinctive characters.

These two specimens were found at the base of a large tree under bark and small rocks. No other specimens were seen.

Hemiphyllodactylus insularis sp. nov. Plate I, figs. 6 and 7; text fig. 4.

Type.—No. 490, male, E. H. Taylor collection; collected at Sumagui, Mindoro, May 20, 1916, by E. H. Taylor.

Description of type.—Head oviform, much longer than broad, less than twice as high as wide; snout slightly longer than its distance from the auricular opening, one and one-half times the diameter of eye; eye large, pupil vertical; auricular opening small, irregular in shape; rostral much wider than high, subrectangular in shape, slightly notched above; nostril surrounded by the rostral, the first labial, and three nasals; the upper largest, separated from its fellow by two scales; eleven upper labials, last three minute; eleven lower labials; the mental triangular; no distinct chin-shields; scales bordering labials below, somewhat enlarged; granules on the snout distinctly larger than those on the back; latter minute, granular, equal; scales on belly cycloid, imbricate, larger than those on body above; no fold on body from axilla to groin; limbs rather small, failing to touch when adpressed; digits rather broad; the penultimate digit has two series of lamellæ, about four under the longest finger, followed by one or two paired scalelike lamellæ; longest toe with four lamellæ followed by two paired scales; a straight series of femoral pores on each side, ten on right, nine on left side, and a slightly angular series of eight preanal pores; tail cylindrical, tapering gradually.

Color in life.—General body color above light brown made up of varicolored scales—some brick red, whitish, black, brown,

and yellow; a series of brick-red dark-edged spots begins behind the eye and continues to tail; upper and lower labials dark, with a series of red spots along each jaw; pupil vertical, coppery red; belly and chin yellowish brown with numerous brown scales. Tail above with a large basal, red, black-edged spot; tail lighter with a dim series of paired lighter spots to the tip.

Measurements of Hemiphyllodactylus insularis sp. nov.

	mm.
Total length	56
Snout to vent	30
Tail	26
Head length	9
Head width	5
Foreleg	8
Hind leg	10.5
Axilla to groin	19

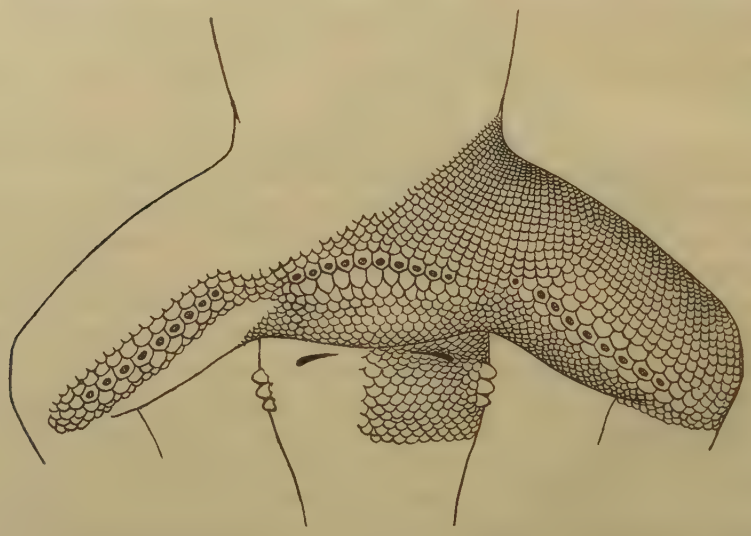

FIG. 4. *Hemiphyllodactylus insularis* sp. nov., type from Mindoro, preanal and femoral pores. × 10.

Variation.—Very little variation is shown in the three other specimens taken in Mindoro. Five specimens taken in Jolo Archipelago are referred to this species. They are from the following localities: Cancuman, Dipolod, Marongas, and Bubuan (Tapian Group). They differ somewhat among themselves and also from the type in color. Specimens from the first three localities are light gray with a distinct black streak passing above labials through the eye and with a second along the canthus rostralis also passing through the eye, meeting at a point at the base of head medially; back mottled with darker color; a distinct dark spot on the base of tail above; the light spots

(red in the type) are evident in these specimens. The first row of scales bordering the labials is slightly larger than in the type. One is a male with ten to twelve femoral pores and seven preanal pores.

The Bubuan specimen is dark brown with darker brown reticulations; a short orange line behind the eye and small orange spots on the sides; a light, dark-edged mark on the base of tail above, as in the type.

Remarks.—This species is very closely allied to *H. leucostictus* Stejneger, if actually distinct. I have no Hawaiian specimens, but Stejneger's excellent description and drawings of the type are at hand.[1] The following differences are evident: The anterior labials are larger, and the posterior smaller, than in *leucostictus;* the eye is nearer the ear opening than end of snout; lateral scales on tail not pointed and raised, the preanal pores in a curved instead of an angular line. There are two or (usually) three scales separating the supranasals. The specimens from Sulu Archipelago have the chin-shields slightly enlarged, and in one specimen a single large scale follows the mental. All of these specimens were found along the seashore under bark of trees exposed to sun and usually reached by the sea water at high tide. Two small eggs are laid. These are joined to each other and attached under the bark of trees. The eggs are rather dirty or brownish white; the undeveloped eggs in the females are brown.

Lepidodactylus woodfordi Boulenger. Plate I, figs. 4 and 5.

Lepidodactylus woodfordi Boulenger, Proc. Zoöl. Soc. London (1887), 334, Pl. 28, fig. 1; DE ROOIJ, Rept. Ind.-Aust. Arch. (1915), 1, 51.

Description of species.—(From No. 1541, Bureau of Science collection). Head oviform, with a broad shallow groove on snout; a distinct depression between nostrils; rostral bent back over point of snout, broadly entering the nostril, highest at the suture with internasal; nostril surrounded by rostral, first labial, a supranasal, and two postnasals; supranasals separated by a single large scale, with a pair of small scales on each side; ten to twelve upper labials; mental differentiated in shape, but not larger than adjacent labials; ten lower labials, the last two or three of both upper and lower labials very small; largest chin-shields are four in number, one pair bordering the mental, the second immediately posterior to first pair (these scales are not equal, but vary in size); other scales touching these enlarged ones are smaller, rounding; granules on snout much larger than those on occiput

[1] *Proc. U. S. Nat. Mus.* (1899), 21, 800, figs. 7, 8, 9.

TABLE I.—*Specimens of Hemiphyllodactylus insularis sp. nov.*

No.	Locality.	Sex.	Snout to vent.	Axilla to groin.	Lamellæ under fourth toe.	Preanal pores.	Femoral pores.	Eye nearer ear than mouth.	Upper labials.	Lower labials.	Internasals.	Collection.
			mm.	*mm.*								
490	Mindoro Island	♂	30	19	5	8	9–10	Yes	11	11–10	2	E. H. Taylor.
489	do	♀	32.3	17	4			do	10	10–11	2	Do.
491	do	♂	31	17	4	10	9– 9	do	10	10–11	3	Do.
	do	♂	34	19	4	8	10–10	do	10–11	10–11	3	Do.
	Cancuman Island	♂	30	15	5	7	12–10	do	10–11	10–10	3	Bureau of Science.
	do	♀	34.2	18.5	4			do	12–12	12–12	3	Do.
	Dipolod Island	♀	36	20	5			do	11–10	11–11	3	Do.
	Marongas Island	♀	33.5	18.2	5			do	10–10	9–11	3	Do.
	Bubuan Island	♀	34	18.2	5			do	12–11	10–11	3	Do.

or body; scales on belly large, cycloid, imbricate; scales on the tail arranged in transverse series, larger below than above, all larger than those on body; annulations indistinctly marked by series of slightly enlarged scales; scales on regenerated portion of the tail irregular and no annulations marked; a continuous series of twenty-four preanal and femoral scales in the preanal region, forming an angle medially; limbs moderately long, meeting when adpressed; digits well developed; inner toe long, well developed, lacking terminal digit and claw; third and fourth toes nearly equal; digits widened at ends, rather slender proximally, only a slight trace of web present; nine lamellæ under inner toe, the first single, the four following divided, last four narrower, rather scalelike; twelve under fourth toe, first four divided followed by three broad undivided lamellæ, these in turn followed by five scalelike lamellæ on the proximal portion of digit, not extending to the base. Eye large, distinctly nearer ear than snout, its diameter about one and one-half times in its distance from snout; ear opening very small, somewhat larger than nostril; tail rather cylindrical, noticeably flattened above and below, with a slight medial depression above and below; no lateral fringe, but the scales on the outer edge slightly raised.

Color in life.—Above gray with variegated scales of brownish and black and six black, irregular, zigzag lines across the back with lighter color between them; one or two indistinct darker lines across the snout and a few dark markings on occiput; a distinct black line from the nostril through the eye, which continues above the ear to the foreleg; tail pinkish gray with a series of dim transverse darker bars and a row of median black spots; also lateral rows of spots; below nearly uniform yellowish cream; labials with lighter spots.

Measurements of Lepidodactylus woodfordi Boulenger.

	mm.
Total length	71
Snout to vent	35.5
Axilla to groin	17.5
Tail, tip regenerated	35.5
Length of head	9.5
Width of head	7
Foreleg	9.5
Hind leg	14.5

Variation.—The seventeen specimens at hand show comparatively little variation; the number of pores or pore scales varies between twenty-one and twenty-five, the average being twenty-three. Occasionally they form a broad angle medially, but

usually the series is curved; the two median scales are largest and frequently are slightly separated. Upper and lower labials vary between ten and twelve. The scales between the supranasals are usually reduced to one large circular scale (only four specimens show exception). The arrangement of the chinshields is usually in two irregular curved rows, most of the enlarged scales are anterior to a line drawn from the posterior part of third labial across jaw. The regenerated tails have the scales arranged irregularly, the annulations not marked; the tail is much wider than deep in cross section. In color the specimens range from brown with rather heavy dark zigzag bars with lighter bars between to very light gray specimens with a few darker markings on back and no trace of zigzag lines; the young are dark laterally.

Remarks.—I have referred this group of specimens to Boulenger's species, since I can find no differences of any import between them and the published description and drawings of the type by Boulenger.[2] The color pattern shown on Boulenger's figure is almost identical with markings of living adult specimens taken. If the specimens are correctly identified, as I believe they are, they represent an interesting addition to our fauna. The nearest territory where they are known is New Guinea, the type locality being Faro Island, Solomon Islands.

TABLE II.—*Specimens of Lepidodactylus woodfordi Boulenger.*

No.	Locality.	Sex.	Snout to vent.	Head.		Axilla to groin.	Foreleg.	Hind leg.	Upper labials.	Lower labials.	Preanal scales or pores.
				Length.	Width.						
			mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*			
1526	Santa Cruz Island	♂	40	10	6.8	20	10.5	16.2	10	11–12	24
1527	do	♂	39	10	7.5	18	11.8	17	11	10	21
1529	Great Govenen Island	♀	41	10.2	7.3	21.2	11.5	16	11	11	22
1530	Bubuan Island	♀	40	10	7.1	20	12	16	10–11	11–12	23
1531	do	♀	37	10	7.2	19	11	15.6	12	11	25
1532	do	♂	38	10	7.2	20	11.2	15.4	11	11	23
1534	do	♂	40	10	7.5	20	12	17	12–12	11	24
1537	do	♀	36	9.2	6.3	19.1	10	14	10	10–11	24
1540	Dipolod Island	♂	35	9	7	17	11	15.5	11–10	12–10	22
1541	Sipayu Island	♀	35.5	9.5	7	17.5	9.8	14.5	10–12	10	24

Lepidodactylus divergens sp. nov. Plate I, figs. 1, 2, and 3.

Type.—No. 2026, female, Bureau of Science collection; collected on Great Govenen Island, 1917, by E. H. Taylor.

[2] Loc. cit. Boulenger states that his specimen has no distinct web, but his fig. 12 shows a distinct rudiment as is present in Sulu specimens.

Description of type.—Head elongate, oviform; snout rather flattened, with a median groove; rostral more than twice as wide as high, rather low medially above, but raised on each side in front of nostrils; latter surrounded by rostral, first labial, two supranasals, and a large postnasal; the supranasals bordering rostral separated by three equal-sized scales; twelve upper labials; a row of scales bordering upper labials above, somewhat enlarged; twelve lower labials; the mental longer but narrower than adjacent scales; a group of enlarged shields under point of chin, the three pairs following the mental largest; almost all enlarged scales are anterior to a line drawn across chin from the sutures between fourth and fifth labials; granules on throat small, about equal to those on occiput and somewhat irregular in size; scales on belly cycloid, imbricate; in the preanal region a long series of preanal scales angular medially; tail much wider than deep, rounding above, noticeably narrowed at the base; flattened below with indications of a slightly sharp, dimly serrated lateral edge, the scales arranged in transverse rows, those above much smaller than those below, the annulations only dimly marked; limbs fairly well developed; digits well developed, except inner, which lacks the distal phalanx and claw; digits slightly wider distally; about ten lamellæ under inner toe, the outer single, the five following divided by a median suture; fifteen under fourth toe, five outer divided; diameter of eye contained in distance from eye to snout two and one-fifth times; eye to ear much less than distance from eye to end of snout.

Color in life.—Above russet to darker brown with numerous darker, narrow, zigzag lines, nine or ten from occiput to base of tail, with lighter areas between them, broad darker bands on tail, about eight to tip; a dark brown line from nostril through eye, which broadens slightly and continues some distance on neck; a yellow line above the brown, quite distinct behind eye; a row of yellow spots dorsolaterally from neck to base of tail; a few yellow flecks laterally; below yellowish, speckled with brown; variegated reddish brown on underside of tail.

Measurements of Lepidodactylus divergens sp. nov.

	mm.
Total length	80
Snout to foreleg	16.5
Snout to vent	41.5
Tail	38.5
Axilla to groin	20
Width of head	7.3
Length of head	12
Foreleg	11.2
Hind leg	16.2

Variations.—Table III shows clearly the variations in a series of nearly equal-sized specimens. Twenty-five specimens were taken, and all are females. All except two were taken on Little Govenen Island.[3] These all showed the characteristic zigzag markings, and usually three short longitudinal dark stripes were present between the shoulders; the series of yellow spots were present on all specimens taken; the three scales between the supranasals are frequently replaced by a single large scale; there is also variation in the arrangement of the chin-shields, but the three pairs following the mental are usually largest. There is slight variation in the length of the snout; sometimes the diameter of eye is contained in the eye to snout distance less than two times. Regenerated tails are flatter and have a sharper, more prominent, serrated edge than normal specimens.

Remarks.—Not a single male specimen was found.[4] This is especially surprising in view of the fact that so large a series was taken and in such a restricted locality. No explanation seems possible save that the males have different habits from the females and occupy some habitat that could not be discovered. All specimens seen were captured, so it could not be explained by their greater agility in escaping capture. This is another species "closely allied to *L. lugubris*," but differs from it in several points. There is a much larger series of preanal scales (pores in males?); there are nearly twice as many lamellæ under the fourth toe (fifteen in the type). The color pattern is distinctly different; the body is crossed by the series of zigzag lines instead of having two median rows of spots present; there is invariably present a series of small yellow spots dorsolaterally on the body. A comparison of descriptions shows other differences.

[3] Little Govenen is an extremely small island lying less than a kilometer from the southwest coast of Basilan Island. It contains only a few hundred square meters of land and rises to an elevation of about 15 meters. On my first visit twelve specimens of this species were taken on the bare rocks that jut from one side of the island. All of these, apparently, were females, and later a special trip was made to the island for the purpose of discovering the males. On this trip the entire island was searched, and eleven specimens were taken. These, too, were females. Later two more specimens were found on Bubuan Island and these also were females.

Many of the specimens contained partly developed eggs, and the sex of these could not be questioned; certain specimens were dissected by myself and others by Dr. E. S. Ruth, of the University of the Philippines, who pronounced all of them females.

[4] In this connection one notes that of fifteen specimens of *Lepidodactylus lugubris* listed by Boulenger [*Cat. Liz. Brit. Mus.* (1885), 1, 165–166] only one is a male.

TABLE III.—*Specimens of Lepidodactylus divergens sp. nov. in the Bureau of Science collection.*

No.	Locality.	Sex.	Snout to vent.	Head.		Axilla to groin.	Fore-leg.	Hind leg.	Labials.		Pre-anal scales.
				Length.	Width.				Upper.	Lower.	
			mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*			
1542	Great Govenen Island	♀	40	11	7	17.3	12.2	16	11-12	11-12	33
1543	do	♀	42.5	12	7	20.8	13	15.6	12-13	11-12	33
1545	do	♀	43.5	12.2	7.8	22	12.5	16.2	11-12	11-13	32
1544	do	♀	43	12	7.2	20.2	14.5	17	12	12	35
1546	do	♀	44	12.2	7.3	22.6	13.2	17	12-13	12	33
1547	do	♀	42	11.5	7	22.2	12.2	17.5	12	12	32
1548	do	♀	40	11.8	7	21.8	12	16.3	12	11-12	33
1549	do	♀	43.8	12	7.8	22.8	13	17.2	12	12-13	32
1550	do	♀	41	11.5	7.1	20.8	12.5	16.5	12	11	32
1551	do	♀	40	11.3	7.2	19.8	12	15.1	12	11	34
1554[a]	do	♀	41.5	12	7.3	20	11.2	16.2	11-12	11-12	34

[a] Type specimen.

Draco rizali Wandollek.[5] Plate II, figs. 3 and 4.

I have referred to this species the common *Draco* of Zamboanga and certain islands to the south.[6] Males and females differ greatly in color. I append color descriptions of both sexes.

Female.—Metallic iridescent gray with dim narrow blackish brown reticulations, sometimes forming dim brownish bands across the back; a few indistinct whitish spots laterally; a large nuchal spot usually present, an interorbital dark spot, and dark markings or reticulations on side of head; shoulders with or without a greenish wash; tail gray to brown with broad fairly distinct bars of darker brown; belly cream-white reticulated with darker color; throat and chin reticulated with bluish. Wing membranes above, black slightly washed with gray, inclosing bright reddish to orange spots, lighter next the body and of deeper color near outer border; below light, with a light wash of yellow and several small black spots near upper and outer border.

Male.—Brilliant yellow-green, somewhat metallic, with occa-

[5] The type was collected by Dr. Jose Rizal in Dapitan and was sent to the Dresden Museum together with other herpetological material. It was named for him by Wandollek.

[6] I have not compared these with the type, but with a splendid photograph of the type taken by Professor Austin Craig, the plate of which is deposited in the Philippine Library. I was permitted to have prints made through the kindness of Professor Craig.

sional scales of lighter and darker color. Wing membranes darker with numerous (usually) roundish spots of bluish to yellowish green, the outer edge light salmon washed with gray. Head with the interorbital dark spot; the nuchal spot absent; dark markings either present or absent on the sides of the head. Below, belly and wing membranes salmon to brick-red, usually with only one large or small dark spot in the outer margin of wing; gular appendage canary yellow at tip, the remainder bright purple to wine color with a green wash at base; throat and chin with darker reticulations; belly with very dim reticulations of darker color either present or absent.

The males can make extremely rapid changes of color. They change from light to dark green, then to black or reddish brown in less than a minute and vice versa. When the brown specimens are placed in alcohol, the green returns largely and when fixed is blue green to blue, the salmon largely disappearing below. In consequence of the color changes the head markings vary considerably in preserved specimens.

The species was abundant in the coconut groves near the mountains in Zamboanga. Specimens were also taken on Bongao and Simonor. On the latter island they were especially numerous in the coconut trees. With the aid of the Samals a large series was collected in the village of Tubig Indangan. The species was seen in Jolo, but no specimens were acquired.

Draco bimaculatus Günther. Plate II, figs. 1 and 2.

A single specimen was obtained in the mountains near Zamboanga (city). It is the smallest species of the genus found in the Islands. It was also observed in Tawitawi. The paper-white gular appendage and the slender body render it easily identified at a considerable distance.

Draco cornutus Günther.

This species has been reported from Jolo by Werner.[7] I failed to find it there.

Mabuya multifasciata Gray.

Specimens were taken in Zamboanga, Bubuan (Tapiantana Group), Jolo, Bubuan (Tapian Group), Papahag, and Bongao. Specimens from the last two localities have a broad brilliant brick-red stripe beginning behind the eye and continuing some distance along the side. It is present in both sexes. Those found on the other islands sometimes have an orange or light spot laterally, but it is absent in females.

[7] *Mitt. Natur. Mus. Hamb.* (1910), 27 (2), 9.

Mabuya multicarinata Gray.

Taken at Zamboanga, Santa Cruz, Basilan, Great Govenen, Bubuan (Tapiantana Group), Dipolod, Bitinan, Jolo, Bubuan (Tapian Group), Bongao, Papahag, and Simonor. I am certain that I observed this species in Sitanki and on the coast of British North Borneo, near Tunku Point. These southern specimens differ but little from those in the more northern Philippine Islands, save that the scale rows are thirty-two to thirty-four, while the usual counts are twenty-eight to thirty in northern specimens.

Mabuya rudis Boulenger. Text fig. 5.

Mabuia rudis Boulenger, Cat. Liz. Brit. Mus. (1887), 3, 188, Plate 11, fig. 3; DE ROOIJ, Rept. Ind.-Aus. Arch. (1915), 1, 161.
Mabuia lewisi BARTLETT, Crocod. Liz. Borneo (1895), 93.

This is the first record of this species for the Philippines. In consequence, I have appended a description of it.

Description of species.—(No. 344, Bureau of Science collection; Papahag Island). Rostral rather small, wider than high, well visible above, slightly in contact with the frontonasal; internasal present, small, elongate, not in contact; frontonasal slightly broader than deep, in contact with the frontal behind; prefrontals rather large, separated, touching first and second supra-oculars; frontal narrow, elongate, not as wide as the supra-ocular region, much longer than the distance to end of snout, and longer than the parietal region; frontoparietals distinct, rather elongate, longer than the interparietal; parietals wider than long, not forming a suture behind the interparietal; a pair of large nuchals; four supra-oculars, the first much reduced, not touching the frontal; second very large, the only supra-ocular touching the frontal; nostril in a rectangular nasal pierced behind the vertical of suture of rostral and first labial; a postnasal; two frenals, the anterior much higher than the nasal, much smaller than second; two preoculars between first superciliary and the fourth labial, superior small; four labials anterior to large subocular; six lower labials, first small, third much elongate; mental narrow, followed by a postmental and two pairs of divided chin-shields, first pair in contact; temporals not or but slightly enlarged; six superciliaries, the first and third much the largest; lower eyelid scaly; ear moderate, tympanum deeply sunk, lobules projecting; scales in thirty rows around the body all keeled except the ten ventral; head scales somewhat rugose. Legs well developed, the adpressed hind limb reaches slightly beyond the

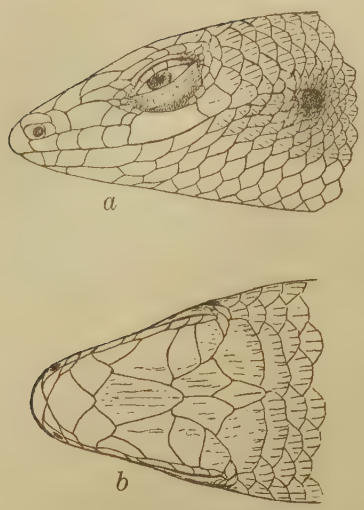

FIG. 5. *Mabuya rudis* Boulenger, from Sulu; *a*, side of head; *b*, top of head. × 2.

shoulder; fourth toe much longer than third with twenty unicarinate lamellæ below. Anals not or but slightly enlarged; tail long, somewhat compressed, tapering very quickly behind anus; eye nearer the ear than end of snout; ear much nearer the foreleg than end of snout.

Color in life.—Above, head and body dark brown with some scales flecked with black; below, throat and chin bluish with black flecks, belly yellowish with black spots on many of the scales; underside of legs and base of tail grayish brown.

Measurements of Mabuya rudis Boulenger.

	mm.
Total length	229
Snout to vent	93
Snout to foreleg	34
Tail	136
Axilla to groin	44
Width of head	15
Length of head	22
Foreleg	35
Hind leg	50

Variations.—Two other specimens have been captured: one, an adult from Tawitawi; the other, a young example from Papahag. The first specimen does not differ from the described specimen save that the black spots on the back form continuous dotted lines, and there is a bright orange band along the side (greenish in alcohol). Throat bluish with indistinct bluish longitudinal lines; labials with black spots; tail flecked with white. The young specimen is olive green, with a broad black stripe beginning behind the eye; sides of neck and body greenish; below greenish white. De Rooij, (op. cit.) states that the range of scale rows is between thirty and thirty-six.

Remarks.—This species was first observed on Bitinan, a small island near Jolo, Sulu Archipelago. It was also observed on Jolo and on most of the islands visited to the south. The first specimen was taken on Tawitawi. It appears to be very common, but is extremely difficult to capture. It does not replace

either of the other species of *Mabuya, multicarinata* or *multifasciata,* since the three occur with the same apparent frequency on the islands from Bitinan to Sibutu Channel. I did not observe any of the three species on the Sibutu Group between Sibutu and Alice Channels, but I do not doubt that they are present, since the three species are known to occur in Borneo. Many of the specimens seen showed the anterior part of the body bright russet to orange; in others the orange was only present low on the sides of the body. It is extremely elusive, and specimens shot with an air rifle usually managed to escape. Unlike *M. multicarinata* and similar to *M. multifasciata* it takes refuge in holes in the ground, which are probably burrows made by it. It occurs in Sumatra, Java, Borneo, and Celebes. In the Philippines it is known only from Sulu Archipelago.

Sphenomorphus fasciatus Gray.

Several specimens were taken in Zamboanga and on Teipono Island. In both places they were found burrowing under logs.

Sphenomorphus variegatus Peters.

Specimens were obtained in Zamboanga and on Bubuan (Tapiantana Group), Bitinan, Jolo, Sangasanga, Tawitawi, and Bongao.

Sphenomorphus palustris Taylor. Text fig. 6.

Specimens were taken at Zamboanga and on Great Govenen and Bubuan (Tapiantana Group) Islands, but none was taken or observed farther south. It was present on the two islands named in large numbers. All have forty scale rows around the body and the distinct black and cream stripes on the side of head; the limbs have narrow light stripes on a blackish brown ground color. The hind limbs are almost black in adults. There are numerous transverse rows of light scales on the sides with black areas between them.

Sphenomorphus biparietalis sp. nov. Text fig. 7.

Type.—No. 1991, E. H. T. collection; collected on Lapac, Sulu Archipelago, September 28, 1917, by E. H. Taylor.

Description of type.—Head short; snout truncate; the rostral rather small, forming a broad straight suture with the fronto-nasal; latter wider than deep, minutely in contact with the frontal; prefrontals large, barely separated, touching minutely the first supra-ocular; frontal much longer than broad, scarcely as wide as the supra-ocular region, in contact with two supra-oculars; frontoparietals large, distinct, touching three supra-

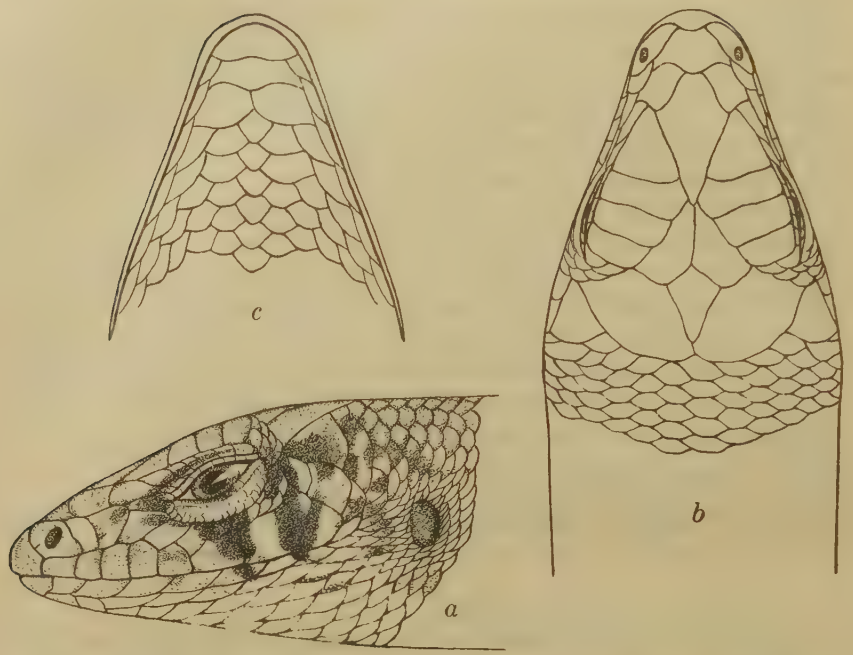

FIG. 6. *Sphenomorphus palustris* Taylor, from Sulu; *a*, side of head; *b*, top of head; *c*, chin. × 3.

oculars; interparietal small, longer than wide, parietals nearly rectangular, broadly in contact with each other behind the interparietal; a second pair of parietals between the first pair and the last supra-ocular, this pair much smaller, in contact with the frontoparietals, the last supra-ocular, and one or two small temporals; no nuchals; nostril pierced in a single nasal; nasal followed by one frenal; the latter followed by two preoculars between first superciliary and second labial; the lower largest; behind this a row of seven subequal scales separating the labials from the orbit; six upper labials, the third, fourth, and fifth below the eye; six lower labials; the temporals slightly enlarged; mental small, followed by a broad postmental; two pairs of chin-shields, both broad, first pair in contact broadly; ear opening large, round, tympanum not deeply sunk; limbs weak, failing to meet when adpressed by a considerable dis-

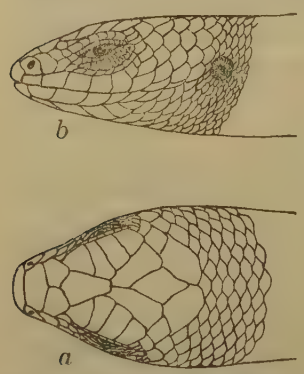

FIG. 7. *Sphenomorphus biparietalis* sp. nov., from Sulu; *a*, top of head; *b*, side of head. × 4.

tance; thirty-two scale rows around body, those on belly largest, lateral rows in straight longitudinal lines; preanal scales not enlarged; third and fourth toes almost of equal length, ten smooth lamellæ under each; scales on underside of tail not enlarged; ear much nearer the foreleg than end of snout.

Color in life.—Above brownish, many of the scales flecked with whitish; a more or less distinct light-dotted line from behind eye along side; below this a stripe of slightly darker brown flecked with white; belly cream, underside of tail flecked with brown; upper and lower labials with light spots.

Measurements of Sphenomorphus biparietalis sp. nov.

	mm.
Total length	70
Snout to vent	35
Snout to foreleg	11.5
Tail	35
Axilla to groin	21
Width of head	5
Foreleg	8
Hind leg	11

Variations.—Eleven other specimens are at hand for comparison. They are from various localities in the Archipelago, distributed as follows: Basilan, 1; Jolo, 4; Lapac, 2; Tawitawi, 1; Sangasanga, 1; Papahag, 2; Bongao, 1. The Basilan specimen is darker and is more heavily built; the head slightly broader, and scales in thirty-six rows about body; the prefrontals are broadly in contact; throat with black spots; two frenals present on right side. Specimens from Jolo are lighter, the two lateral light lines being more or less distinct. The type is from Lapac. Specimens from the more southern part of the Archipelago vary from thirty to thirty-four scale rows about the body. The labials vary between five and six.

Remarks.—This species seems to be very clearly differentiated by the arrangement of the parietals, which is different from that of any other species in the Islands. The only lizard in which this condition is approached is *Brachymeles vermis* Taylor, found on Papahag, near Tawitawi.

Riopa bowringi Günther. Text fig. 8.

Eumeces bowringii Günther, Rept. Brit. Ind. (1864), 91.
Euprepes (Riopa) punctatostriatus Peters, Mon. Berl. Ak. (1871), 31.
Lygosoma bowringii Boulenger, Cat. Liz. Brit. Mus. (1887), 3, 308; Plate 23, fig. 3; de Rooij, Rept. Ind.-Aus. Arch. (1915), 1, 264.
Lygosoma whiteheadi Mocquard, Le Natural. (1890), 12, 144; and Nouv. Arch. Mus. (1890) (3), 2, 134, Plate 8, fig. 3.

Description of species.—(No. 1990, Bureau of Science collection; collected at Siet Lake, Jolo, September 22, 1917, by E. H. Taylor). Snout rather obtuse, the rostral slightly visible above; supranasals present, in contact behind rostral; frontonasal much broader than long, broadly in contact with the frontal; prefrontals present, very small and very widely separated, leaving the frontal in contact broadly with the frontonasal; frontal longer than broad, as long as interparietal and frontoparietal; parietals in contact behind the latter; a pair of nuchals, and a large temporal borders the parietals; nostril pierced in a rectangular nasal, followed by two frenals, the anterior higher than the nasal and the posterior frenal; two preoculars between the first superciliary and fourth labial; seven superciliaries; four supra-oculars, the first broadly in contact with the prefrontal; lower eyelid scaly; seven upper labials, the fifth large, below the eye; fourth as small as first; three or four enlarged temporals; six lower labials; mental rather wide, followed by a wide postmental; three pairs of divided chin-shields, the first pair in contact, the third small; ear opening small, with two projecting lobules; twenty-six rows of scales about middle of body, all smooth; preanal scales somewhat enlarged; scales on underside of tail slightly larger than those above; limbs rather small, the fourth toe only a little longer than third; thirteen lamellæ under fourth toe; tail thick, tapering very gradually. Eye nearer the end of snout than ear; the latter nearer the insertion of the foreleg than end of snout; adpressed limbs fail to meet by a considerable distance.

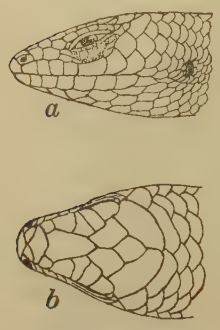

FIG. 8. *Riopa bowringi* Günther, from Jolo; *a*, side of head; *b*, top of head. × 3.

Color in life.—Above yellowish to dark brown, the scales on each dorsal row with black spots, forming more or less regular longitudinal dark lines; a broad black line begins behind the eye and continues above limbs to some distance on tail; scale row above black line, lighter than ground color; below black line, indistinct lines of brown with numerous distinct yellow punctations and occasional reddish brown scales; below orange to pink; rather pinkish in groin; a distinct white line along the upper labials.

Measurements of Riopa bowringi Günther.

	mm.
Total length (extreme tip of tail regenerated)	84.5
Snout to vent	42
Snout to foreleg	15
Axilla to groin	25
Tail	41.5
Width of head	5.1
Length of head	7.2
Foreleg	10
Hind leg	12.7

Variations.—Five other specimens from Jolo Archipelago are in the collection. They agree with the above description with few exceptions. One specimen has two pairs of nuchals, a second has the frontoparietals fused. All save the one described have twenty-eight scale rows. A young specimen in the collection is olive brown above. None of the specimens show evidence of carinations on scales.

Remarks.—This is the first record of this species from the Philippines. Its occurrence is hardly a matter of surprise, since de Rooij has identified Mocquard's *Lygosoma whiteheadi* from North Borneo as a synonym of this species.

The specimens obtained in Jolo Archipelago are from the following islands: Siet Lake, Jolo, 2 specimens; Lapac, 1; Bongao, 1; Simonor, 1; Tawitawi, 1. This species is also known from Borneo, several localities; Java; Celebes; Malacca; Siam; Burma; Hongkong.

Emoia atrocostatum Lesson.

It was observed or taken on all the islands visited; especially common along the coasts; numerous specimens were preserved.

Emoia cyanurum Lesson.

This species was taken only on Tulian, a small uninhabited rocky island near Jolo. It was not observed elsewhere. In the Philippines it is common on certain islands along the coast of Palawan. It is a matter of no small surprise that it was not taken or observed on the other Sulu Islands. If it is present, it is probably rare. Two of the specimens taken have brilliant blue tails with three greenish golden stripes on the back from snout to tail.

Dasia smaragdinum Lesson. Plate III.

Specimens were taken on Great Govenen and Bongao Islands. In the first locality they were especially numerous. Dorsally

the specimens are bluish green, anteriorly with many irregular dark spots mixed with small black spots and many smaller flecks; posteriorly the ground color is olive green to brown, the spots rather disappearing or uniting to form larger more regular spots; tail greenish.

The specimens from Bongao are olive to brownish green above with large black spots on the back of the head and many quadrangular black spots on the back with similar greenish white spots; tail olive gray with annulations dimly marked with whitish spots. Neither of these forms can be placed with the color varieties described and admirably figured by Barbour.[8]

Tropidophorus rivularis Taylor.

A number of specimens were taken near Zamboanga. They agree with the type, except that the interparietal is not divided.[9] I did not find this species in Sulu Archipelago. It is highly probable that this or a related species does occur on those islands that have running water. Species of this genus are constantly found along small fresh-water streams, usually under partly submerged rocks or logs.

Brachymeles suluensis sp. nov. Text fig. 9.

Type.—No. 1989, female, Bureau of Science collection; collected on Bubuan Island,[10] Tapiantana Group, Sulu, by E. H. Taylor.

Description of type.—Snout blunt, rather flattened; rostral bent back over end of snout, forming a moderate suture with the frontonasal; the latter longer than broad; prefrontals narrowly in contact, wider than deep, touching both frenals, first superciliary, and first supra-ocular; frontal large, a little longer than broad, in contact with two supra-oculars, narrowly in contact with the interparietal; the latter little longer than wide, much larger than the frontoparietals; parietals elongate, narrowly in contact behind the interparietal; no nuchals; nostril pierced in a minute nasal, followed by a small postnasal; anterior frenal nearly twice as large as the second; a small preocular between the first superciliary and the third labial; five supra-oculars, second largest and widest; five or six superciliaries; six upper labials, first largest, fourth below eye; two small scales above the fifth labial; mental deeper than postmental, but not as wide; three pairs of chin-shields, the first

[8] *Mem. Mus. Comp. Zoöl.* (1912), 44, Pls. 1 and 2.

[9] Probably anomalous in the type.

[10] There are two islands in Sulu Archipelago by this name, one is in the Tapiantana Group, the second lies to the south in the Tapian Group.

pair in contact; second pair widest, separated by a single scale; third pair separated by three scales; ear opening minute, nearer end of snout than foreleg; twenty-four rows of smooth scales around body; preanals slightly enlarged; limbs pentadactyl, the anterior very short, reaching little more than halfway to ear; three scales above longest finger; five above longest toe; third and fourth toes subequal in length. Hind leg contained in axilla to groin distance five times.

Color in life.—Above and below light brown, each scale with a large slightly darker spot; a lighter stripe from behind eye to hind leg.

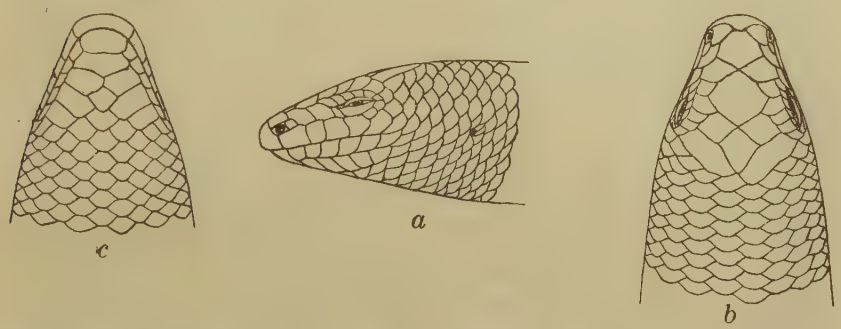

FIG. 9. *Brachymeles suluensis* sp. nov. Type from Bubuan; *a*, side of head; *b*, top of head; *c*, chin. × 3.

Measurements of Brachymeles suluensis sp. nov.

	mm.
Total length	117
Snout to vent	81
Snout to foreleg	19
Tail, broken	36
Axilla to groin	55
Width of head	6.3
Foreleg	6
Hind leg	11

Remarks.—Only the type was found; it is an adult female containing embryos. This species forms another link in the chain of retrogression in the genus *Brachymeles.* It is between *Brachymeles schadenbergii* and *B. bicolor* and differs from both in the degree of development of the limbs and the relative length of the body.

Brachymeles vermis sp. nov. Text fig. 10.

Type.—No. 1980, Bureau of Science collection; collected at Bubuan, Tapian Group, Sulu, October 1, 1917, by E. H. Taylor.

Description of type.—Rostral about as high as wide, bending back over point of snout, visible above by more than half its

height; frontonasal broader than deep, broadly in contact with the rostral, narrowly with the frontal; prefrontal wider than long, narrowly separated, touching two frenals, first superciliary, and first supra-ocular; frontal slightly longer than wide, in contact with two supra-oculars and the interparietal; the latter longer than broad, inclosed by the parietals, with a prominent eyespot, larger than frontoparietals; latter separated, touching two supra-oculars; a pair of nuchals present; parietals more than three times as long as wide; five supra-oculars, first largest, second widest, last three touching the parietal; nostril pierced between the large supranasal and first labial (if a nasal scale is present it is apparently indistinguishable); two frenals, first nearly twice as large as the second; one large preocular; only two anterior superciliaries distinguishable; six upper labials, first very large, third and fourth below the eye; a scale partially inserted between the fourth and fifth labials; mental large, extending back to the vertical of near suture between first and second upper labials; four lower labials; postmental smaller than mental, touching one labial; three pairs of chin-shields,

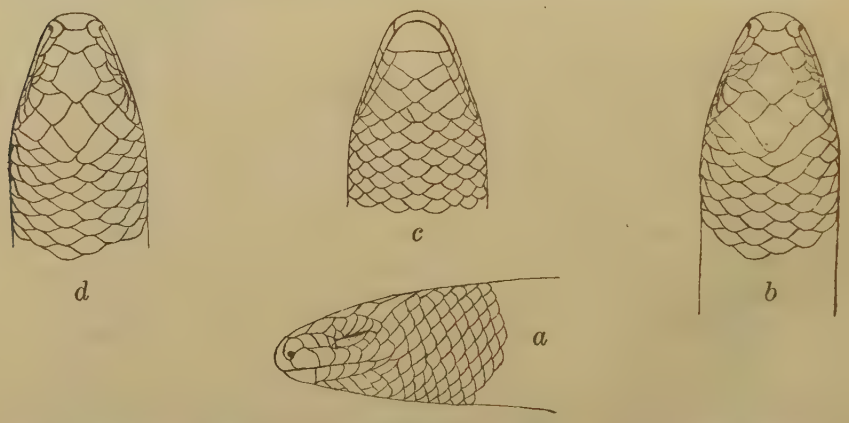

FIG. 10. *Brachymeles vermis* sp. nov., from Sulu; *a*, side of head; *b*, top of head (normal); *c*, chin; *d*, top of head (variation of Papahag specimens).

none in contact, second pair broadest, first two separated by a single scale, third pair by three scales; temporals slightly enlarged, two touching parietal; twenty-two scale rows around body, all smooth; preanals slightly enlarged. No limbs present; a slight depression laterally on either side of the anus with two or three elongate scales. No auricular opening; scales on anterior part of snout thickened.

Color in life.—Above light brown, each scale with a darker brown spot, making broken longitudinal lines; belly the same, slightly lighter.

Measurements of Brachymeles vermis sp. nov.

	mm.
Total length	144
Snout to vent	86
Tail	58
Width of head	4
Width of body	5

Variation.—Specimens were obtained in four localities: Bitinan, 3 specimens; Lapac, 4; Bubuan (south island), 3; and Papahag, 4. All show variations. Bitinan specimens have twenty-four rows of scales, and two have the nuchals much elongated and only one temporal touching the parietal; Lapac specimens have twenty-six scale rows; one specimen has the parietal broken on one side; Bubuan specimens, including the type, twenty-two scale rows; Papahag specimens all have the parietal broken in two parts. The first pair is small, about the size of the prefrontals; the second posterior pair elongate, forming the normal suture; they have twenty-two to twenty-four scale rows about the body.

Remarks.—This species is closely related to *Brachymeles burksi* Taylor and *Brachymeles bonitæ* Gray. It carries the retrogression of the genus another step, and we find the evolution complete from the highest developed forms, *Brachymeles gracilis* and *schadenbergii,* with well-developed pentadactyl limb, to this small legless form.

Brachymeles gracilis Fischer.

One specimen was obtained on Great Govenen Island and three specimens on Jolo Island. They agree very well with those from Negros and Mindoro. The hind leg is contained in the axilla to groin distance an average of three and one-tenth times; the development of the digits is slightly less than in northern specimens. It is a matter of no small surprise to find this species in Sulu Archipelago, as the known Mindanao species is *B. schadenbergii.*

Dibamus argenteus Taylor.

One specimen taken on Papahag; a second specimen was found at Tunku Point, British North Borneo.

SNAKES

Typhlops braminus Daudin.

Specimens were taken at Zamboanga and on Bongao.

Typhlops suluensis sp. nov. Text fig. 11.

Type.—No. 2001, Bureau of Science collection; collected on Bubuan, Tapian Group, Sulu, October 2, 1917, by E. H. Taylor.

Description of type.—Snout rather pointed, with a moderately sharp edge; rostral nearly one-half the width of the head, rather truncate behind, forming a broad straight suture with the prefrontal; the latter very large, broadly triangular in shape, its longest sutures with the preoculars; frontal very small, bordered by six scales, about one-fifth the size of the prefrontal; interparietal as wide as the prefrontal, but somewhat smaller; supra-ocular slender, about two and one-half times as long as broad; parietals much larger than supra-oculars, little more than twice as long as wide; nasals separated, their upper ends barely extending beyond the posterior level of the rostral, which reaches almost to the anterior level of the eyes; nasal completely divided by the nasal cleft, which arises from the first labial; preocular in contact with two labials, not as wide as the ocular, its upper end scarcely reaching higher than the upper level of

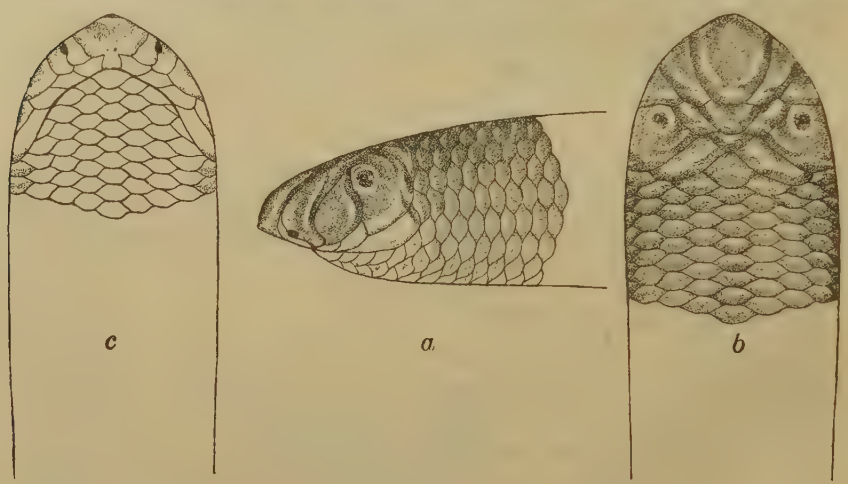

FIG. 11. *Typhlops suluensis* sp. nov.; *a*, side of head; *b*, top of head; *c*, underside of head.

eye; eye distinct, with a minute pupil visible, not crossed by the suture of ocular with preocular; two body scales border the ocular behind; four lower labials, the second scarcely larger than the first; scales in twenty-two rows around middle of body; twenty on neck; twenty-two in front of anus; tail ending in a sharp spine.

Color in life.—Above dark drab gray covering nine whole and two half rows of scales, each scale with a slightly curved lighter area, which forms a fine-meshed network over the body, balance of body very light gray, the ventral median row of scales differentiated by being much lighter in color, with the outer edges and the edges of the adjacent scale rows slightly darker; occa-

sionally an entire scale is white in the median ventral row; tip of tail and anal region whitish; underside of head rather light dirty white; head with lighter curved markings arranged regularly, following somewhat the sutures of the head scales.

Measurements of Typhlops suluensis sp. nov.

Total length (mm.)	340
Tail (mm.)	13
Width of tail (mm.)	5.5
Width of body (mm.)	7.4
Width of the head (mm.)	5.5
Tail width in tail length (times)	2.4
Body width in body length (times)	46
Tail length in body length (times)	26

Remarks.—The type was obtained on Bubuan, Tapian Group, in Sulu Archipelago. It was found in a rotten log only about 4 meters from the high-tide mark on the beach. Much effort was made to obtain other specimens on this island, but none was found. This species seems to be most closely related to *Typhlops multilineatus* and *T. olivaceus*. From the former the following differences are evident: The rostral is shorter, the nasal completely divided, the diameter of body contained in total length forty times (in *multilineatus* fifty to sixty times), twenty-two instead of twenty scales around middle of body; the prefrontal larger, the frontal smaller; the color is not arranged in longitudinal lines. From *T. olivaceus* it differs in the complete division of the nasal, the preocular much narrower than the ocular, the rostral barely half the width of the head; the color is also different.

Python reticulatus Schneider.

No specimen taken. Reported as being present on Tawitawi, Basilan, and Jolo, where they are said to be fairly common.

Xenopeltis unicolor Reinwardt.

A mutilated specimen of what is presumably this species was brought to me by a Samal, in Bongao. Most of the head is missing, but the following body characters agree largely with specimens of this rare snake from Palawan. Ventrals, 168; anal divided; subcaudals, 28; scale rows, 15; three lower labials in contact with the anterior chin-shields. Body somewhat flattened, deep blue-black above, the three lateral rows of scales white-edged; outmost row white, with dim dark dots; ventrals white; a few scattered dark spots on the posterior part of body. Underside of tail black, the scales with white edges. Length,

325 millimeters; tail, 42. Known heretofore in the Philippines only from Palawan and Balabac.

Cyclocorus lineatus Reinhardt.

A specimen of this common species was taken in the mountains near Zamboanga.

Ablabes tricolor Schlegel.

One specimen of this very rare species was taken on Bubuan Island, Tapian Group. It was at rest in the branches of a low shrub. It agrees in remarkable detail with specimens from Palawan in regard to head scales. Ventrals, 137; anal divided; subcaudals (tip of tail missing), 103.

Holarchus meyerinkii Steindachner.

A single specimen of this rare snake was taken on Papahag Island, near Bongao. I regard this form specifically distinct from *Holarchus octolineatus* Schneider.[11] The species is also known from Tawitawi. The type locality is "Sulu Archipelago."

Dendrophis pictus Gmelin.

One specimen taken on Lapac; a second on Cagayan Sulu.

Dendrelaphis modestus Boulenger.

A single male specimen was taken on Bubuan, Tapian Group; it agrees very well with the type description in regard to scalation of head. The dark streak on the side of the head is very dim; there is a bright orange streak along the anterior part of body (almost disappearing in alcohol); ventrals, 175; tail with tip missing.

Elaphe erythrura Duméril and Bibron.

Three specimens of this species were taken in Bongao. It is reported as being common there.

Calamaria gervaisii Duméril and Bibron.

A single specimen was collected on Cagayan Sulu.

Psalmodynastes pulverulentus Boie.

Two specimens were obtained from near the top of Bongao Mountain, at an elevation of 700 meters. Both were under a small log. They show very marked color variations. One is very dark with slightly lighter mottlings; the other is gray

[11] See *This Journal, Sec. D* (1918), 13, No. 6 (in press).

with black spots and two light streaks behind the eye along both sides of the neck, continuing for the greater part of the distance along the body.

Crysopelea ornata Shaw.

One specimen was obtained on Bubuan, Tapian Group; it is nearly uniform olive above, with each scale black-edged.

Laticauda colubrina Schneider.[12]

This snake was obtained on several islands. Many were observed in crevices in rocks, where they could not be readily taken; a large series was preserved.

Doliophis philippinus Günther.

A young specimen was taken in the mountains near Zamboanga.

NOTES ON ISLANDS VISITED

As most of the localities mentioned in this paper are recorded only on the Coast and Geodetic Survey chart, I append the following notes:

Zamboanga.—Province and town, southwest Mindanao. Collections were made in the mountains near Zamboanga, near or on the water reservation. Several specimens were also taken in the city of Zamboanga.

Santa Cruz Islands.—Two small, low islands lying off the coast of Mindanao about 2 kilometers from the city of Zamboanga. Covered with low brush. Few inhabitants.

Tictauan.—Very low, covered with dense mangrove forest; no land, very little beach, covered almost wholly with water; no inhabitants; 4 kilometers off Zamboanga.

Basilan.—A very large mountainous island almost entirely forested, 10 kilometers from Mindanao, separated by a channel, its greatest depth about 44 fathoms. Collections were made on the island at a point directly across from the mainland and on a rocky hill on the coast opposite Govenen Islands.

Great and Little Govenen.—Two islands, the first lying only a few hundred meters from the southwest coast of Basilan, the second less than a kilometer away. The first is a conical peak rising to about 200 meters, forested on top, cultivated on the

[12] A large sea snake, probably of this genus, but of a different species, was observed swimming on the surface of the water near Bubuan Island (Tapian Group). The waves were running rather high, and the launch was upon the reptile before it was observed. It disappeared below the surface.

sides; the smaller island is only a few meters high and contains a few hundred square meters.

Teipono.—A low, flat coral island, 3 kilometers off the west coast of Basilan; very small, no inhabitants.

Tamuk.—Somewhat larger than Teipono; forested; 4 kilometers from Basilan; a ring of low land inclosing a larger swamp about the higher interior. Greatest elevation, 60 meters.

Cancuman.—A small flat island lying between Tamuk and the coast of Basilan, inhabited by a few families of Samals; forested.

Tapiantanas.—A group of islands lying from 4 to 10 kilometers south of Basilan; consists of three mountainous islands and a large flat coral island. Collections were made on Bubuan on the western side of the island. Elevation, 264 meters; heavily forested; greatest diameter, 2 kilometers. Very few or no inhabitants. Some wild boar.

Dipolod.—A very small, conical, rocky island in the Samales Group. Forested; no inhabitants; 22 kilometers from Basilan.

Mamanoc.—A small, low, flat island; one of the Samales Group, 0.5 kilometer long.

Bitinan.—A mountainous island off the northeastern coast of Jolo. Forested; uninhabited; elevation, 241 meters; has many wild cattle, no wild boar.

Jolo.—Large, mountainous, volcanic islands second to Basilan in size in the archipelago. Separated from the Samales Group by a channel 8.5 kilometers wide and at least a hundred fathoms deep. Collections made at Siet Lake and at Crater Lake, in the central part.

Marongas.—A small island 5 kilometers northeast of the port of Jolo; 92 meters high; low forest or brush.

Tulian Rock.—Seventy meters high, 50 meters wide, 200 meters long; low brush.

Bolipongpong.—An island in the Northern Tapul Group, separated from Jolo by a channel about 25 fathoms deep and 17 kilometers wide. The island is 7.2 kilometers long and 4 kilometers wide; elevation, 338 meters; forested. I stopped on the extreme southwestern point.

Lapac.—An island 30 kilometers south of Jolo. Partly forested; largely covered with cogon fields; inhabited. Collections were made on the extreme northern coast.

Tapaan.—A low coral atoll, covered with brush and mangrove; uninhabited. No reptiles were seen.

Bubuan, Tapul Group.—A mountainous, forested island; no inhabitants; elevation, 155 meters; 3 kilometers long and about

as wide. Reptiles especially abundant; collections were made on the southern and southeastern coasts.

Tawitawi.—A large mountainous island, 40 kilometers long; its greatest width, 15 kilometers. Heavily forested. I collected on the extreme southern point.

Bongao.—A small island separated from Sangasanga by a channel a few meters wide, which affords a passage for small boats and launches. Forested; inhabited; an elevation of 330 meters. Collections were made near the town of Bongao and on the large mountain of the same name.

Simonor.—A rather large, low, flat island, 9.5 kilometers south of Tawitawi, separated from nearby islands by water more than 40 fathoms deep. Collections were made at the town of Tubig Indangan.

Sibutu.—A very long, narrow island lying southwest of Tawitawi; separated from it by Sibutu Channel, 28 kilometers wide and more than 100 fathoms deep; it is low, flat, and heavily wooded. A single small peak rising to a height of 165 meters; distant from the Bornean mainland, 29 kilometers. Collections were made on the western coast.

Sitanki.—A very small island surrounded by a great, shallow reef, separated from Sibutu by a deep, narrow channel; distance from the Bornean mainland, 41 kilometers.

Sipayu.—A very small, low sandy island separated from Tawitawi by a few hundred meters. Covered with brush and low trees.

Sangasanga.—A large island at the southern end of Tawitawi, separated by a channel only a few meters wide, which affords passage for barotos and vintas; forested. I collected on the southern end.

TABLE IV.—*Lizards and snakes known from Sulu Archipelago.*

[X, collected by Taylor; O, observed by Taylor; R, reported by others.]

Species.	Zamboanga.			Basilan.					Tapiantanas.	Samales.		Jolo.				Siasi.		Tapaan.	Tawi Tawi.										
	Zamboanga.	Great Santa Cruz.	Tictauan.	Basilan.	Great and Little Govenen.	Teipono.	Tamuk.	Cancuman.	Bubuan.	Dipolod.	Mamanoc.	Bitinan.	Jolo.	Marongas.	Tulian.	Bolipongpong.	Lapac.	Bubuan.	Sipayu.	Sangasanga.	Tawitawi.	Papahag.	Simonor.	Bongao.	Sibutu.	Sitanki.	Cagayan Sulu.	Borneo.	
LIZARDS.																													
Gymnodactylus annulatus	O	×		×	×	×	×	×	×	×	×	×	×		×			×	×		×	×		×					
Gekko gecko	O	O											×	×		O													
Gekko monarchus																								×					
Cosymbotus platyurus	×			×																			×	×	O	O		×	
Hemidactylus frenatus	×	×			×								×						×					×				×	
Peropus mutilatus	×	×		×					×				×					×						×				×	
Luperosaurus joloensis													×																
Hemiphyllodactylus insularis								×		×				×				×											
Lepidodactylus woodfordi		×			×					×	×							×	×										
Lepidodactylus divergens					×													⁄											
Draco rizali	×												O										×	×					
Draco bimaculatus	×																O			O	O								
Draco cornutus																													
Calotes cristatellus																									×		O		
Mabuya multicarinata	×	×	O	×	×	O			×	×		×	×						O		O		×	×		O	×		
Mabuya multifasciata	×	O											×					×			O	×		×					
Mabuya rudis												O				O	O	O		O	×	×		O					
Sphenomorphus palustris	×			O	×				×				O																

Sphenomorphus variegatus	X								X			X	X							X	X			X			O	
Sphenomorphus fasciatus	X					X																						
Sphenomorphus biparietalis				X									X				X			X	X	X	X	X				
Riopa bowringi													X				X							X				
Emoia atrocostatum	X	X	O	O	O	O		O								X		X	X					X		O		
Emoia cyanurum															X													
Dasia smaragdinum	O				X				X			O	O									O	X	X	X	O		
Tropidophorus rivularis	X																											
Brachymeles gracilis					X								X															
Brachymeles suluensis									X																			
Brachymeles vermis												X					X	X				X						
Dibamus argenteus																						X						X
Hydrosaurus pustulosus	O																											
Siaphos infralineolatus	O	X		X	X			X		O	X	X	X		X		X	X										
SNAKES.																												
Typhlops braminus	X	X																						X				
Typhlops suluensis																		X										
Python reticulatus	R												R															
Xenopeltis unicolor																								X				
Cyclocorus lineatus	X																											
Dendrelaphis modestus																		X										
Dendrophis pictus																	X										X	
Elaphe erythrura																								X				
Ablabes tricolor																		X										
Holarchus meyerinkii																					R	X						
Calamaria gervaisii																											X	
Psalmodynastes pulverulentus																								X				
Crysopelea ornata																		X										
Laticauda colubrina										X					X		O	X										
Doliophis philippinus	X																											

ILLUSTRATIONS

PLATE I

FIGS. 1, 2, and 3. *Lepidodactylus divergens* sp. nov., from Great Govenen.
4 and 5. *Lepidodactylus woodfordi* Boulenger, from Bubuan.
FIG. 6. *Hemiphyllodactylus insularis* sp. nov., type, from Mindoro. Enlarged.
7. *Hemiphyllodactylus insularis* sp. nov., from Bubuan. Enlarged.
8. *Luperosaurus joloensis* sp. nov., type, from Jolo. Enlarged.

PLATE II

FIG. 1. *Draco bimaculatus* Günther, female, from Mindanao.
2. *Draco bimaculatus* Günther, male, from Mindanao.
3. *Draco rizali* Wandollek, female, from Simonor.
4. *Draco rizali* Wandollek, male, from Simonor.

PLATE III

FIG. 1. *Dasia smaragdinum* Lesson, variety, from Great Govenen.
2. *Dasia smaragdinum* Lesson, variety, from Mindanao.
3. *Dasia smaragdinum* Lesson, variety, from Bongao.

TEXT FIGURES

FIG. 1. *Gymnodactylus annulatus* Taylor, from Sulu, preanal pores, variation. × 3.
2. *Gymnodactylus annulatus* Taylor, from Mindanao, preanal pores, typical. × 3.
3. *Luperosaurus joloensis* sp. nov., cotype from Jolo, preanal pores. About × 4.
4. *Hemiphyllodactylus insularis* sp. nov., type from Mindoro, preanal and femoral pores. × 10.
5. *Mabuya rudis* Boulenger, from Sulu; *a*, side of head; *b*, top of head. × 2.
6. *Sphenomorphus palustris* Taylor, from Sulu; *a*, side of head; *b*, top of head; *c*, chin. × 3.
7. *Sphenomorphus biparietalis* sp. nov., from Sulu; *a*, top of head; *b*, side of head. × 4.
8. *Riopa bowringi* Günther, from Jolo; *a*, side of head; *b*, top of head. × 3.
9. *Brachymeles suluensis* sp. nov., from Sulu; *a*, side of head; *b*, top of head; *c*, chin. × 3.
10. *Brachymeles vermis* sp. nov., from Sulu; *a*, side of head; *b*, top of head (normal); *c*, chin; *d*, top of head (variation of Papahag specimens).
11. *Typhlops suluensis* sp. nov.; type; *a*, side of head; *b*, top of head; *c*, underside of head.

PLATE I. PHILIPPINE LIZARDS.

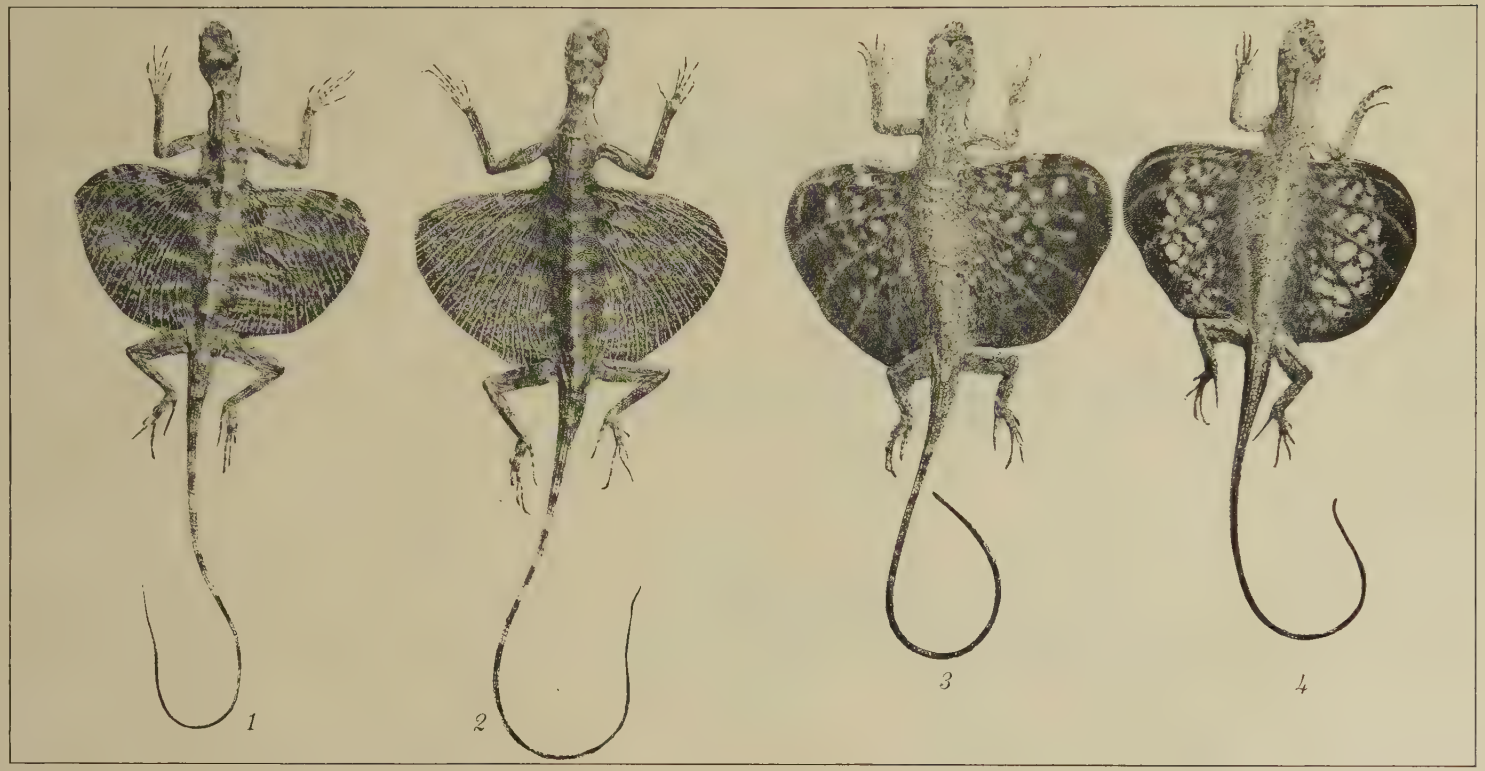

PLATE II. PHILIPPINE DRACOS.

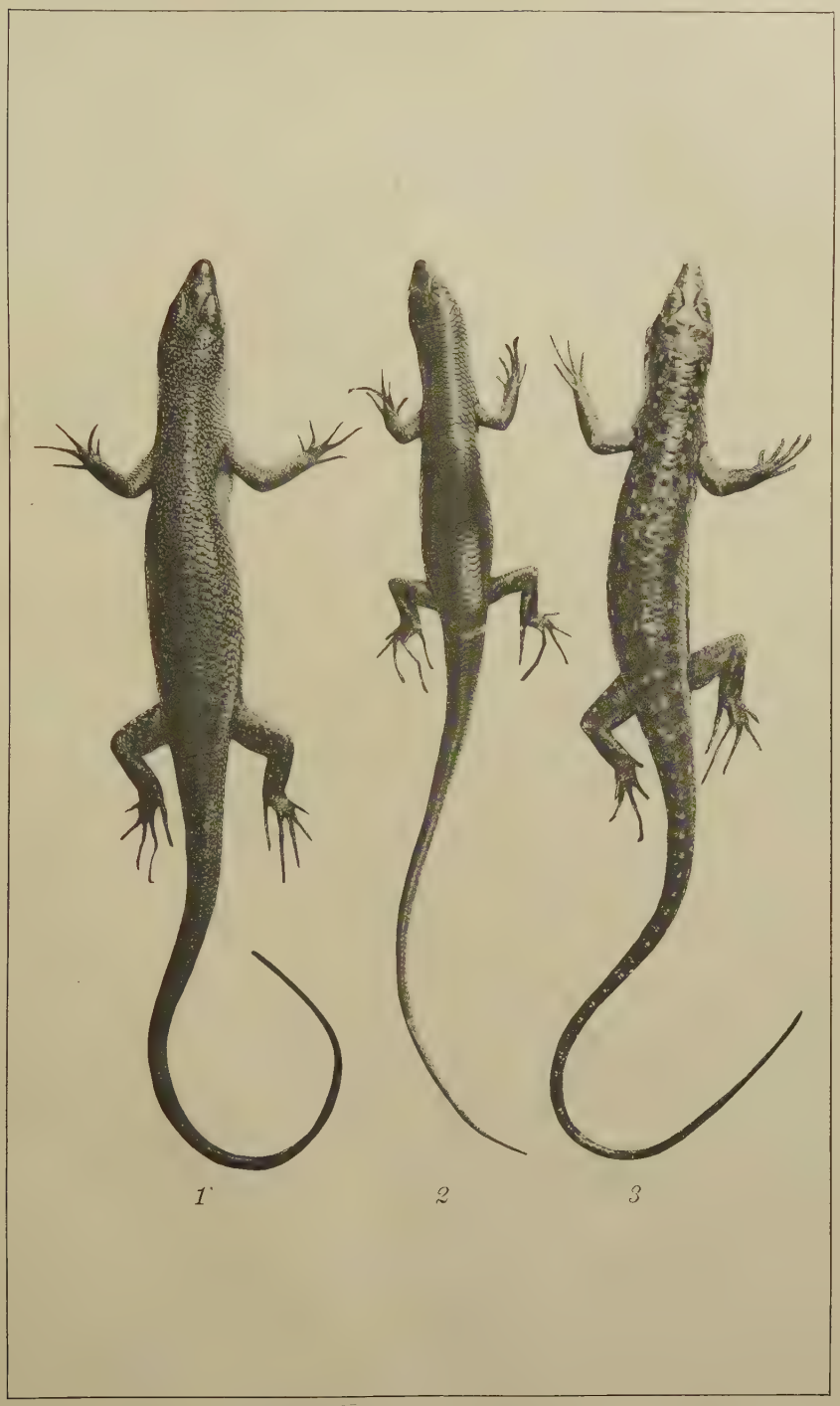

PLATE III. PHILIPPINE LIZARDS.

FIFTH CONTRIBUTION TO THE COLEOPTERA FAUNA OF THE PHILIPPINES

By W. SCHULTZE

(*Manila, P. I.*)

ONE PLATE

The genus *Alcides* Dalmann has been so far represented in the Philippine Islands by the following species:

A. albocinctus Blanch.
A. burmeisteri Bohem.
A. crassus Pasc.
A. decoratus Roel.
A. delta Pasc.
A. leucospilus Erichs.
A. ocellatus Roel.
A. pectoralis Bohem.
A. rutilans Roel.
A. semperi Pasc.
A. septemdecimnotatus Roel.
A. smaragdinus Roel.
A. waltoni Bohem.

The above list seems rather small, in view of the fact that most of the Philippine *Alcides* are conspicuously colored and marked. Due to their peculiar coloration several authors [1] have mentioned certain species of the above genus in comparison with species of the almost exclusively Philippine genus *Pachyrrhynchus*. The diversity among certain groups of species [2] of the genus *Alcides* found in the Philippines as well as among those of other localities is noteworthy. For that reason it would be well to divide this large genus into subgenera should it be treated monographically.

In the Philippine Islands three main groups [3] of species of *Alcides* are easily recognized, besides certain rather isolated forms. The first and largest group comprises species that are subcylindrical in general appearance, such as *A. albocinctus* Blanch. and *A. delta* Pasc. The second group consists of rather stout species, having greater shoulder width than forms of the first or third group and having for the most part, a conspicuous

[1] Pascoe, *Journ. Linn. Soc. London* (1870), 10, 462. Roelofs, *Tijdschr. voor Entom.* (1893), 36, 34. Bovie, Wytsman's Genera Insectorum (1908), fasc. 71, 2.

[2] Pascoe, *Ann. & Mag. Nat. Hist.* (1882), 9, 451.

[3] This statement is based on over forty Philippine species of *Alcides* in my collection.

metallic luster. Species such as *A. ocellatus* Roel., *A. semperi* Pasc., *A. septemdecimnotatus* Roel., and *A. smaragdinus* Roel. belong to this group. The third group consists of species that are oval in appearance, represented by *A. pectoralis* and *A. waltoni* Bohem.

So far nothing seems to have been published of the biology of the Philippine *Alcides* species. For that reason the following may be of interest.

BIOLOGICAL NOTES ON ALCIDES SEMPERI PASCOE

Alcides semperi Pasc. inhabits the mountainous regions of central Luzon. It lives on *Aralia hypoleuca* Presl.,[4] which is found scattered about in the ravines and valleys in the neighborhood of Baguio. On several occasions my attention was attracted to this plant by the dried-up appearance of the young shoots, usually one or two in number. I also noticed that from near the tip of the shoots a resinous substance was exuding. Upon close examination and by cutting the nearly dried-up tips, which is a rather disagreeable work, since the plant is beset very closely with very acute stiff thorns, I found a larva feeding on the pith, working from the top downward. The stem was hollowed, according to the size of the larva; in the case of a full-grown larva the hollowed-out part measured from 30 to 40 centimeters in length. Full-grown larvæ pupated readily in captivity. The adults that emerged proved to be *A. semperi.* The egg is evidently laid in the tip of the young shoot of the plant, the larva proceeding in the above-mentioned manner, feeding on the pith. During March and April I found the larvæ to be from half- to full-grown. In two cases I observed that the pupal stage lasted from ten to twelve days. The pupa is rather lively and is able to move freely up and down in the hollowed-out stem. After casting off the pupal skin, the beetle emerges only after three or four days have elapsed. Even then it is soft, and the markings are very faint and develop gradually as the beetle attains its natural hardness. The adults are common around Baguio during May and June, the beginning of the rainy season.

Two rather striking variations are prevalent, between which intermediate forms are very rare. One form is marked with rings,[5] which are usually well separated from each other; and the other form is marked with round spots, which are large and

[4] Kindly determined by Prof. E. D. Merrill.

[5] Bovie, Wytsman's Genera Insectorum (1908), fasc. 71, fig. 3.

closely approach each other. The variation with the rings seems to be common around Baguio, whereas the one with the spots is found more in higher altitudes.

NEW PHILIPPINE ALCIDES SPECIES

The species hereafter described belong, with the exception of the last one, to the first group, characterized by the subcylindrical shape.

Alcides mindanaoensis sp. nov. Plate I, fig. 4.

Subcylindrical, black. Rostrum apically sparsely, toward the base coarsely and densely, punctured. An indistinct carina beyond the middle and an elongated depression terminating between the eyes, the latter with a punctiform impression. Vertex of head finely and uniformly punctured. Prothorax coarsely but sparsely punctured on the apical area, but the punctuation very coarse and confluent toward the base and lateral margins, almost granulate. A semicircular whitish band laterally less pronounced in the discal part. Elytra striate-punctate, the punctures coarse near the base. Each elytron in the basal half with a broad band arising posterior to the scutellum, extending obliquely to the lateral margin. Another curved band, at the second third of the elytra, interrupted at the suture. Apical triangle with a broad V-shaped spot. Underside densely punctured and beset with whitish scales. Legs sparsely punctured, finely and sparsely setose.

Length, 13 millimeters (without rostrum).

Width, 5.3 millimeters.

MINDANAO, Davao (*C. M. Weber*). Type in my collection.

Alcides insularis sp. nov. Plate I, fig. 5.

Subcylindrical, glossy black. Rostrum very finely and sparsely punctured. A shallow depression with a punctiform impression between the eyes. Prothorax closely and strongly punctured, the punctuation gradually confluent toward the base and the lateral margins. A creamy white almost round spot, laterally, near the apex and a narrow posterior marginal band. Elytra striate-punctate and finely rugose. Each elytron with a narrow band arising at the suture posterior to the scutellum, running obliquely, not quite reaching the middle, recurving toward the lateral margin, though not quite reaching the latter. Another band at the last third of each elytron from near the suture to near the lateral margin. Apical triangle with a V-

shaped stripe, the outer branch of which is very short. Underside densely and irregularly punctured, prothorax beset with creamy white scales. Spots at the lateral margins of the meso- and metathorax and abdominal segments, except the anal. Legs very glossy, finely and scatteredly punctured.

Length, 10 millimeters (without rostrum).

Width, 3.5 millimeters.

CATANDUANES ISLAND, Virac. Type in my collection.

Alcides merrilli sp. nov. Plate I, fig. 8.

Subcylindrical, black. Rostrum rather short, very finely punctured in the apical half, strongly and irregularly punctured toward the base and on the head. A fine carina in the basal half terminating in an oblong pit between the eyes. Prothorax granulate, except the apical area, where it is irregularly punctured, the surface covered with small irregular patches of scattered ochraceous scales. Elytra striate-punctate, moderately pronounced and coreaceous. The apical third of the elytra covered with rather regular small spots of scales. The underside is also coriaceous. The legs are glossy, relatively short and stout, and strongly and irregularly punctured.

Length, 9.5 millimeters (without rostrum).

Width, 3.5 millimeters.

LUZON, Zambales (pine region of Zambales Mountains). Type in my collection.

I name this interesting species in honor of the indefatigable Philippine botanist, Prof. Elmer D. Merrill.

Alcides mindorensis sp. nov. Plate I, fig. 1.

Subcylindrical, bluish black. Rostrum very finely punctured apically, coarsely toward the base. A shallow pit between the eyes. Vertex of head very finely and densely punctured. Prothorax sparsely punctured at the anterior margin, but granulate toward the posterior and lateral margin. A creamy white oblong spot at the anterior margin laterally and a band at the posterior margin. Elytra striate-punctate, well pronounced, the interstices finely rugose. Each elytron with a broad band, arising posteriorly of the scutellum and extending obliquely to the middle of the lateral margin. Beyond the middle another cross band, which is confluent with the former laterally, but separated again at each lateral margin. Apical triangle with a broad V-shaped stripe. Legs irregularly punctured.

Length, 13.5 millimeters (without rostrum).

Width, 5 millimeters.

MINDORO, Mansalay (*Edward H. Taylor*). Type in my collection.

Alcides luzonensis sp. nov. Plate I, fig. 7.

Subcylindrical, robust, glossy bluish black. Rostrum rather short, finely and sparsely punctured at the apex, coarsely and densely punctured laterally and at the base. A medial carina in the basal half terminating in a depression between the eyes. Vertex of head very finely variolosely punctured. Prothorax closely and coarsely punctured, especially toward the lateral margins. A white band at the fore margin interrupted discally and a posterior marginal band. Elytra striate-punctate, less pronounced than in the preceding species, the interstices finely rugose. A combination of white lines, forming on each elytron a figure like the letter X, the anterior tangents of which are longer than the posterior. The discal anterior tangents arise at the base next to the slightly raised scutellum. The two posterior discal tangents, which are rather short, form a curved transverse band behind the middle. A straight subsutural line in the apical third of each elytron recurved along the lateral margin and confluent with the posterior lateral tangent. Underside closely punctured, prothorax beset with whitish scales, lateral margins of meso- and metathorax and abdominal segments with white spots, forming a band. Legs glossy, irregularly punctured.

Length, 11.5 millimeters (without rostrum).

Width, 4.5 millimeters.

LUZON, Laguna, Paete (*W. Schultze*). Type in my collection.

Alcides tagalicus sp. nov. Plate I, fig. 6.

Subcylindrical, slender, dark castaneous brown. Rostrum, apical half impunctate, basal half coarsely and confluently punctured, a carina terminating in a shallow depression, very finely setose. Vertex of head minutely punctured. Prothorax very coarsely and confluently punctured, except at the apical area. An ocherous white discal lateral line from the anterior to the posterior margin. The same is spotlike, expanded at the anterior margin, and slightly curved. Scutellum roundish, with a punctiform depression. Elytra striate-punctate, the interstices very rugose. The combination of bands very similar to *A. luzonensis*, but more elongated. The bands at the base are continued along the margin, terminating in a spotlike expansion at the

shoulder. Underside very densely punctured and covered with ocherous scales. Legs slender, closely and confluently punctured.

Length, 12 millimeters (without rostrum).

Width, 4.5 millimeters.

LUZON, Rizal, Montalban (*W. Schultze*). Type in my collection.

Alcides catanduanensis sp. nov. Plate I, fig. 2.

Subcylindrical, black. Apical half of rostrum very finely and sparsely punctured, basal half coriaceous with a fine carina, which terminates in a pitlike depression between the eyes. Vertex of head finely punctured. Prothorax very closely and uniformly granulate. A creamy white band, interrupted in the middle, near the anterior margin; another along the posterior margin. Elytra striate-punctate, well pronounced and finely rugose. A sutural band from the base, running for a short distance posterior to the scutellum; it then forks and proceeds obliquely to the middle of each lateral margin. A transverse band at the apical third of the elytra becomes confluent at each lateral margin with the former. A narrow V-shaped stripe in the apical triangle of each elytron, one branch being subsutural, the other submarginal. Underside more or less covered with creamy white scales, especially the prothorax, also the meso- and metathorax and abdominal segments laterally. Legs glossy, very finely and scatteredly punctured.

Length, 14 millimeters (without rostrum).

Width, 5.5 millimeters.

CATANDUANES ISLAND, Virac. Type in my collection.

Alcides schuetzei sp. nov. Plate I, fig. 3.

Subcylindrical, black, very glossy. Rostrum apically finely, basally coarsely and confluently, punctured. Basal half with a distinct medial carina terminating in a pit between the eyes. Vertex of head very finely punctured. Prothorax slightly constricted anteriorly, finely and regularly punctured. A whitish round spot laterally at the anterior margin, another larger spot at the posterior margin. Elytra very finely punctate-striate. Each elytron with five very large, roundish whitish spots, arranged in three cross rows—two basal, two medial, and one in the apical triangle. Underside with a small lateral marginal spot on the metathorax and each abdominal segment. Legs irregularly punctured.

Length, 12.5 millimeters (without rostrum).

Width, 4.5 millimeters.

LUZON, Benguet, Baguio (*O. Schütze*).

Named in honor of its collector.

Alcides taylori sp. nov. Plate I, fig. 9.

Robust, subcylindrical, castaneous brown. Rostrum moderately long, densely and irregularly punctured and rugose, and beset with scattered scales. Antenna with the second funicular joint longest. Vertex of head smooth. Prothorax slightly constricted anteriorly, closely and coarsely granulate, except at the apex. Scutellum rounded and slightly elevated. Elytra a little broader than the prothorax, coarsely punctate-striate, the punctures large and somewhat square, interstices rugose. The apex evenly rounded. A narrow creamy white stripe arising from the apex of the prothorax somewhat laterad, running obliquely to the base. This stripe is continued on the elytra, becoming somewhat broader and extending to behind the middle of each lateral margin, where it becomes expanded and confluent with an arched transverse band. The band is interrupted at the striæ crossings. Underside and legs are densely punctured and beset with scattered scales, especially the abdominal segments. The tooth of the anterior femora is very small; the one on the medial and posterior femora is more pronounced.

Length, 14 millimeters (without rostrum).

Width, 5.8 millimeters.

MINDORO, Mansalay (*Edward H. Taylor*). Type in my collection.

I take pleasure in naming this species in honor of its collector.

In general aspect this species seems to be related to forms like *A. kirschii* Pasc.;[6] from the preceding Philippine species it is easily recognized by the sculptural differences.

Alcides taylori subsp. panayensis subsp. nov.

This subspecies differs from *A. taylori* in the following secondary characters: Thorax with a rather faint creamy white medial line across the disk from the anterior to the posterior margin and a well-pronounced narrow stripe at each lateral margin. On the elytra at the junction of the longitudinal stripe with the arched band the former is continued as a narrower stripe to the apical triangle and terminates in a V-shaped mark.

PANAY, Antique, Culasi (*R. C. McGregor*).

Several specimens of this interesting subspecies were collected by my friend Mr. McGregor in the mountains near Culasi.

[6] Pascoe, *Ann. & Mag. Nat. Hist.* (1882), 9, 449, Pl. 18.

BIOLOGICAL NOTES ON PACHYRRHYNCHUS VENUSTUS WATERHOUSE

For a number of years, whenever collecting *Pachyrrhynchus*, I have endeavored to discover the immature stages of the various species, as well as their food plants and individual habits. To my knowledge there have been no published records on the biology of any species of this genus. As a rule, most species of the *Pachyrrhynchus-Apocyrtus* groups are found congregated in one locality, sometimes in large numbers on their supposed food plants. Since all of the species of the above groups are wingless forms and are, therefore, unable to fly, it seems rather strange that their breeding habits should be so difficult to discover. My efforts to discover something of the life histories of *P. congestus* Pasc., *P. modestior* Behr., and *P. pinorum* Pasc., which are rather common around Baguio, failed entirely; with *P. venustus* I was more successful. This species is found at the fresh-water swamp near Los Baños, the latter being an extension of the large lake, Laguna de Bay. This swamp contains no large trees, but a mass of shrubs, bushes, and a heavy growth of a peculiar fern.[7] The water in the swamp varies in depth from a few centimeters to a half meter or more at certain times. Since I had found most of the *P. venustus* climbing about on this fern, I examined this plant very closely. By cutting the leaves and the old leaf axils and splitting the trunk, or caudex, I finally located the larvæ and one pupa. The larvæ are found in the older, lower part of the trunk, which consists of alternating soft and very hard tissues. The larvæ feed in the soft parts, their channels being very short. The larvæ are oblong and of uniform diameter. The pupa was located in a

[7] Prof. E. D. Merrill kindly determined this fern and furnished the following description:

Acrostichum aureum Linnaeus.

A very coarse tufted fern from thick suberect root-stocks, which often form a distinct caudex. Fronds large, simply pinnate, 50 to 200 centimeters long, the pinnæ oblong, coriaceous, entire, 20 to 50 centimeters long, 4 to 6 centimeters wide, somewhat stipitate, glabrous, apex obtuse to retuse, sometimes mucronate, the midribs stout, the veinlets distinct, freely anastomosing. The upper pinnæ are fertile, wholly or in part, the sporangia densely covering the entire back of the pinnæ or parts of them.

In brackish swamps throughout the Philippines, occurring also about mineral springs inland, such as those at Los Baños, and at Daklan, Benguet Subprovince. Near the seashore in all or most tropical countries. Tagalog name, *lagolo*.

crude pupal chamber near the exterior part of the trunk where the old leaf axils are located. It was creamy white when found, but upon being placed in alcohol, the latter acted as a fixative, since the pupa changed to light brown and the spots on the elytra became distinctly visible (Plate I, fig. 10). In general appearance the pupa is rather elongate. Anterior margin of clypeus and sides of the head beset with a few bristles. The meso- and metathoracical segments dorsally, somewhat laterad, beset with two thornlike tubercles, and the abdominal segments dorsally beset with a series of fleshy tubercles bearing a few short bristles. Anal segment dorsolateral with a more projecting tubercle and several smaller ones, each bearing a long bristle.

The beetles feed on the leaves of the fern, starting at the edges and devouring an oval piece about 2 centimeters long. *Pachyrrhynchus venustus* has the same common habit as have most species of *Pachyrrhynchus*. The beetles in climbing about and being approached at first try to hide by crawling on the underside of the leaf or on the reverse side of the stem, but if approached closely they instantly drop to the ground and remain motionless for some time. In the dense undergrowth it is very difficult to rediscover the beetle when it has dropped. The spots on the elytra of *P. venustus* Pasc. vary in number from 20 to 24 and are very pale lilac-colored.

On the leaves of the same fern I also found the interesting Buprestidæ, *Endelus bakeri* Kerrem.

ILLUSTRATION

[Drawings by W. Schultze.]

PLATE I

FIG. 1. *Alcides mindorensis* sp. nov. × 2.
2. *Alcides catanduanensis* sp. nov. × 2.
3. *Alcides schuetzei* sp. nov. × 2.
4. *Alcides mindanaoensis* sp. nov. × 2.
5. *Alcides insularis* sp. nov. × 2.
6. *Alcides tagalicus* sp. nov. × 2.
7. *Alcides luzonensis* sp. nov. × 2.
8. *Alcides merrilli* sp. nov. × 2.
9. *Alcides taylori* sp. nov. × 2.
10. *Pachyrrhynchus venustus* Waterh., pupa. × 2.
11. *Pachyrrhynchus venustus* Waterh. × 2.

PLATE I. PHILIPPINE COLEOPTERA.